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S.W. Penny. 1909.

NATAL.

SURVEYOR-GENERAL'S DEPARTMENT.

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SECOND REPORT

OF THE

GEOLOGICAL SURVEY OF NATAL AND ZULULAND.

BY

WILLIAM ANDERSON, F.R.S.E., F.G.S.,

GOVERNMENT GEOLOGIST.

Issued by direction of the Hon. Joseph Baynes, C.M.G., Minister of Lands and Works.

LONDON.
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LETTER OF TRANSMITTAL.

Geological Survey of Natal,
January 20, 1903.

Sir,

I have the honour to submit, herewith, the Second Report of the Geological Survey of Natal and Zululand. I have been permitted by the authors, to include two valuable and important additions to the palæontology of the East Coast of Africa, in the Reports of Mr. R. Etheridge, Jun., "On the Cretaceous Fossils of Zululand" (Part I., Umkwelanè Hill); and of Professor A. C. Seward of Cambridge University, England, "On the Fossil Plants of the Coal-bearing Series of Umhlali, Natal." By permission of the General Manager for Railways, Cape Colony, I am able to include the Report I made for the Cape Government, "On the Stormberg Coal-measures to the West of Molteno," in that Colony.

Very respectfully yours,

WILLIAM ANDERSON,
Government Geologist.

J. L. Masson, Esq.,
Surveyor-General.

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LETTER OF TRANSMITTAL.

GEOLOGICAL SURVEY OF NATAL,
January 20, 1903.

SIR,

I have the honour to submit, herewith, the Second Report of the Geological Survey of Natal and Zululand. I have been permitted by the authors, to include two valuable and important additions to the palæontology of the East Coast of Africa, in the Reports of Mr. R. Etheridge, Jun., "On the Cretaceous Fossils of Zululand" (Part I., Umkwelane Hill); and of Professor A. C. Seward of Cambridge University, England, "On the Fossil Plants of the Coal-bearing Series of Umhlali, Natal." By permission of the General Manager for Railways, Cape Colony, I am-able to include the Report I made for the Cape Government, "On the Stormberg Coal-measures to the West of Molteno," in that Colony.

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J. L. MASSON, Esq.,
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INTRODUCTION.

During the earlier months of the year 1901 I was chiefly engaged in office, preparing for the press the First Report of the Geological Survey of Natal and Zululand. The first issue of this Report, consisting of five hundred copies, was published and distributed towards the end of the year; but, owing to the great demand for the publication, a second edition, consisting of three hundred copies, has now been published. The maps and sections were copied by Mr. L. Daviniere, who for some months acted as draughtsman to the Geological Survey. His work in this department was admirable. He proceeded with me, as camp assistant, to Zululand in the month of June, and left the service in the middle of October.

My annual leave occurred from February 25th to March 17th.

In April I visited Dumisa, in the Umzinto District, travelling *viâ* Richmond and High Flats, in order to observe the general geology, on a traverse, from the high plateau to the sea, at a point further south than I had previously had an opportunity of doing. The geological description of this traverse is given below.

In May I visited Durban for the purpose of making an examination of the geology of its neighbourhood, in order to determine if there was any probability of the occurrence of payable coal under the Bluff. This forms a separate report. (p. 165.)

In the end of June I left Pietermaritzburg with my camp, and, journeying through Victoria County, entered Zululand by Bond's Drift, Lower Tugela, and continued the reconnaissance geological survey of that Province. For the purpose of investigating as to the presence of rocks of economic value among the Cretaceous Series, I visited a few points on the coast where outcrops of these rocks were reported to occur—Fort Durnford; to the north of the mouth of the Umhlatuzi river; Cape Vidal; north and south ends of Saint Lucia Lake; False Bay; Sordwana Point; and Lake Sibayi. I returned by the Makowe Hills and Hlabisa, as it was not possible, owing to the activity of the Boers, to work on the western frontier.

Towards the end of November I returned to headquarters.

In December I proceeded to Cape Town to act as one of the examiners in Geology and Mineralogy for the Cape University.

My annual leave occurred in January, 1902.

During March I visited the Richmond District and investigated various localities where gold and coal were reported to occur.

In the beginning of April I visited Ladysmith.

Early in May I left for Cape Colony, the Cape Government having asked for the use of my services to make a geological examination of a portion of the Stormberg Coal-field. I was engaged upon this work until the end of July.

In the beginning of August I left for Zululand, where I continued the reconnaissance geological survey in the north-western and Melmoth Divisions of that Province, returning to headquarters in November, and visiting Cape Town in December to examine in Geology, &c., for the University there.

The office of the Survey is still in the two small rooms in Galway's Chambers. These are inconveniently crowded, and altogether inadequate for the necessary office work of the Geological Survey, and the storage of the necessary specimens, books, &c. Now that the Government have established a Natal Museum, it is natural to suppose that a Geological Department will be formed there. It is therefore desirable that facilities be given to the official Geological Department of the service—the Geological Survey—by providing it with sufficient storage room for specimens of fossils, rocks, and minerals of such a size that they could ultimately be converted into specimens for exhibition purposes, without the necessity of having to go to further expense by sending a collector to the localities previously surveyed by the Geological Survey, to procure specimens for exhibition. Owing to the limited office and storage space which has been placed at the disposal of the Geological Survey since its inception in 1899, no room for the habitation of large specimens has been available. If it had not been for the fact that the various collections of fossils have been sent to palæontologists in various parts of the world, who kindly undertook their identification, the Geological Survey offices at the present moment would practically have been inaccessible. It has therefore been necessary for me, from the first, to restrict myself, in the collecting of rock specimens, to small examples sufficient for the identification of the rock, instead of having been able to acquire those of sufficient size for future development into exhibition specimens. The small hand specimens are sufficient for the immediate purposes of the study and identification of the rock from its micro-section. This latter collection has increased like the others, but as it does not occupy much space its presence does not call for further remark here. It is, however, essential that before the typical rocks of the Colony can be exhibited to proper advantage, specimens of them must be obtained and dressed to the requisite uniform size, so that they may accompany the drawings of their micro-sections, which show their mineral constitution. A record, however, is kept by the Geological Survey of the localities in which specimens of these rocks which are of consequence to the geologist and student occur, so that examples of them can be obtained when necessary.

Large additions have been made to the library during the two years 1901-2. These were all obtained in exchange for the First Report of the Geological Survey. Between four and five hundred volumes of the reports of Geological Surveys and the transactions of Societies, besides pamphlets and maps, all pertaining to Geology, were received. A rough list of these is given further on in this report.

I am still the only member of the staff, and have elsewhere urged upon the Government the necessity for providing me with at least one geological assistant. Now that I have been able to accomplish much of the preliminary work of the survey in reference to the general geology of Natal and Zululand, it is necessary that many districts be taken in hand, examined geologically, and mapped minutely. This cannot be done without some professional assistance, and it is particularly the case with regard to the geological survey of the coal-bearing rocks of the three divisions of the Colony, for extensive coal-fields occur in all three. As I have stated in my first report, this is of extreme importance, and the longer it is delayed the more bogus companies and mining swindles will be perpetrated on the confiding public. It is impossible for the Geological Survey to give any professional opinion as to the merits or demerits of any section of the country as regards its coal-bearing capacity without having had the opportunity of surveying the area geologically in more or less detail. As this could not be done in a thoroughly systematic way, owing to the limited staff, there is at the present no authentic professional geological knowledge of the stratigraphical geology of the various coal-bearing areas of the Natal portion of the east coast of Africa. To this fact is largely due the useless expenditure of money and labour by prospectors, as well as the enormous loss incurred not only by the Government but by private individuals and companies in boring for coal in impossible positions, without the slightest geological evidence in support of the choice even of the locality, let alone the actual site of the bore. During the last few years we have had quite a number of glaring cases of this; and in some instances at least it would seem, to any sensible person, that they were done for swindling or other equally reprehensible purposes.

It will be seen from the above itinerary that during the field seasons of 1901 and 1902 the major portion of my work was confined to the Province of Zululand. This was owing in a great measure to the fact that that country was proclaimed an infected area because of the prevalence of lung sickness, and latterly rinderpest, among stock, thereby preventing the removal of my cattle, &c., back into Natal. I was therefore precluded from furthering the geological survey which I had previously begun in Victoria County, Natal, on the scale of 1 inch to the mile. It has, however, enabled me to carry on the reconnaissance geological survey of Zululand over the whole of the eastern portion of the Province, leaving only the Nkandhla, Nqutu, and Nondweni districts yet to be traversed, together with an area between the Black and White Umfolosi rivers east of Mahlabatini.

Zululand

The results of this rough survey of the greater part of Zululand have been to furnish a preliminary knowledge of the areas occupied by the various geological formations, and an exact idea of those in which it is impossible to expect the occurrence of the heavier and more important commercially valuable minerals, together with those districts in which there is a reasonable possibility of the presence of other economically valuable minerals. The distribution of the coal-bearing formations have been defined in a broad way, but, as I have stated above, the definition of the economic areas among these will prove an important part of the work of the Geological Survey when the Government see their way to provide the necessary professional assistants. Many of the areas consisting of the Ecca Series will have to be mapped specially, on a fairly large scale, in order to define the economic coal-producing portions of these coal-fields, upon which a considerable amount of desultory prospecting by shafts and tunnels has been done. A great deal of useless boring has also been performed in a haphazard fashion, with the usual result, not only of disappointment, but also in many cases of an altogether unjust and entirely erroneous conception as to the actual coal-bearing capacity of the coal-fields, through the non-success of their efforts to prove the presence of coal in the bores which were sunk indiscriminately owing to their want of the necessary geological knowledge.

Besides the fundamental granitic series and the subsequently intruded igneous rocks and lavas, of late Secondary or Tertiary times, I have, up to the present, recognised the following sedimentary formations in Natal and Zululand. The table is shown on page 13, where, for the sake of comparison, I also give the known geological formations of Cape Colony and the Transvaal. For the want of a complete geological survey of the various colonies, which would give an intimate local knowledge of their stratigraphical geology and of the palæontology of their various formations, the correlation of the different divisions and even in some cases of the formations themselves, is not yet finally settled; and it is probable that the correlation of many of them will occasion much controversy among geologists before it is satisfactorily and permanently established. Any correlation of the Metamorphic Series and the various Palæozoic formations in one Colony with another may be taken at the present time as purely provisional, until a more local field knowledge of their stratigraphy, distribution, geological character, and economic value has been obtained. From a local point of view, however, I think that there is now no doubt as to the correlation of the formation spoken of in my first report as "Palæozoic Sandstones," with the Table Mountain Sandstones of Cape Colony, notwithstanding the fact that as yet we have no palæontological evidence to prove this, although the similarity of the petrological characters, occurrence, and the composition of the beds composing the formation, together with the fact that the stratigraphical evidence which is afforded by the outcrops to the south of St. John's river in Pondoland and the Transkie, quite support this idea. The only other division of a pre-secondary formation that can as yet be correlated with any degree of certainty, consists of a series of chocolate-coloured slates with quartzites and auriferous conglomerates, which occur on the Umfolosi river, Zululand, to the west of Ulundi, which probably represent the Hospital Hill Series of the Transvaal as suggested by Molengraaff.

With regard to the representatives of the Secondary and Quartenary periods, on broad lines, they may be accepted as fairly correct. Of course the divisions of the Cretaceous period, for instance, have not yet been worked out on the east coast; in fact, although some of the beds in the Zululand coastal deposits can be distinctly correlated with beds at the St. John's river mouth, as a whole, it is impossible, with our scanty knowledge of the isolated outcrops of the formation, even to give a definite idea of the probable sequence of the series of beds forming it.

So far as is known, we have no conclusive evidences of the presence of Tertiary rocks in any portion of South Africa south of the Limpopo river. It is just possible, however, that some representatives of this period may occur on the northern littoral of Zululand, although at Delagoa Bay the coastal rocks are certainly of Cretaceous age.

[illegible]

The granites with their accompanying gneisses, schists, and less altered quartzites, conglomerates, &c., which are so well developed in the sub-coastal areas of Natal, the Engoye Mountains, and the Melmoth district of Zululand, present characters which are well worthy of mention. In these localities the occurrence of the granite among the gneisses and schists is remarkable, in that it is of a most erratic character. In the Engoye Mountains to the north-east of Eshowe, it is present as a more or less distinct axis to the range, where it is flanked on either side by gneisses and schists. The less metamorphosed rocks of this series to the east and west of the range are not often visible, being covered by the newer formations; but at the Matikulu river mouth in Zululand, a small outcrop of granite occurs, and to the north-west, after crossing the Umhlatuzi river, the large area of the Melmoth district is formed of similar granitic and metamorphic gneisses and schists. Here the granite is not of the ordinary character of a simple intrusion, but is present on the outcrops as local areas among the gneisses and schists. In the Inchanga and Inanda districts of Natal the porphyritic granite there, shows far more evidences of having been a locally intruded granite; while in the Engoye range this feature appears to a less degree.

The gneisses and schists associated so intimately with the local areas of granite seem to be quite distinct from the metamorphic slates, quartzites, jasperoid rocks, and conglomerates which are present in the west of Zululand in the Nkandhla and Tugela Valley districts. The petrological character and mineralogical composition of the granites forming these erratically disposed areas, usually vary much, and there seems little doubt that the gneissic and schistose series of rocks is of a much greater age than the metamorphic rocks, quartzites, jasperoid rock, &c., above mentioned, and probably represents the oldest rocks of the Continent, the original basal series of this part of the world, which formed the backbone of Africa, upon and around which all the younger sedimentary formations have been deposited. On the East Coast there is a tremendous gap between this granitic series, with its overlying metamorphic quartzites, &c., and the sedimentary formations immediately overlying them. This is shown by the unconformity which exists in every case between them and the Table Mountain Sandstones, the glacial Ecca Conglomerate, and occasionally the Ecca Shales, which in different localities overlie the granitic series unconformably.

Whether this most ancient series of granites, gneisses, and schists are the same as the Namaqualand gneisses and schists, I cannot yet say; but my friend Dr. Corstorphine informs me that lately he has identified a similar series of granitic gneisses and schists on the Limpopo river, to the north of Pietersburg. His description of the occurrence and character of these rocks on the Limpopo, tallies exactly with this series on the East Coast which I have just mentioned.

With regard to the Dwyka Conglomerate, I purpose in this report and in future, to use the term Ecca instead of Dwyka, as has been done frequently by some of the older South African geologists. It seems to me to be a more suitable name for a part of the glacial Ecca Series. My reasons for doing so are as follows. The fact that the fossil flora of the upper coal-bearing Ecca Shales is distinctly of a Permo-Carboniferous type would place the glacial conglomerate near the top of the Carboniferous period, which is represented in Cape Colony by the Witteberg Beds. In Natal and Zululand, in the Transvaal, and in the northern portion of Cape Colony there is a decided unconformity between the glacial conglomerate and the rocks upon which it rests. On the east coast, in Natal, this unconformity represents the omission of two formations, the Witteberg and Bokkeveld Beds, which may never have existed there or may have been deposited and subsequently denuded before the accumulation of the glacial conglomerate. It is only in the southern part of Cape Colony, where there has been a conformable sequence of beds from the Table Mountain Sandstones through the Bokkeveld, Witteberg, Glacial Conglomerate and Ecca Shales. In this case, the Witteberg Sandstones pass upwards into the glacial boulder beds of the Eccas above, and these again pass gradually into the shales of the lower Eccas, which have all the petrological characters of a solidified glacial mud. Even here, the striking difference between the character of the Witteberg Sandstones and the glacial Ecca Conglomerate immediately overlying them would mark a decided line of division for the purposes of nomenclature and stratigraphy, notwithstanding the conformity; although they might be with reason kept as Carboniferous deposits among the Witteberg Beds. This I think is, however, hardly desirable, as the Ecca Shales, the flora of the upper portion of which has a decidedly Mesozoic facies, would, for much the same reason, as conformable strata, have to be included among the Witteberg Beds. The unconformity below the glacial conglomerate in the other Colonies would certainly support the idea of separating the Palæozoic Witteberg Beds from the Permo-Carboniferous Ecca Series. Thus the question merely resolves itself into one of retaining the name Ecca for the two divisions of the Permo-Carboniferous glacial deposits, instead of the lower boulder bed being called Dwyka, while the overlying shales are named Ecca. On a point of uniformity the alteration is, I think, desirable, and will be found much more convenient.

Numerous inquiries have been made to me with reference to the

			NATAL.	CAPE COLONY.	TRANSVAAL.
Recent and Pleistocene.			River and Lake Alluvial Deposits; Diatomaceous Earth; Surface Ironstone; Raised Beaches; Wind-Blown Sands of Coast.	River and Lake Alluvial Deposits; Surface Ironstones; Raised Beaches; Wind-blown Sands; Quartzites of Cape Flats.	River and Lake Alluvials; Surface Ironstones and Lime Deposits; Ossiferous Cave Deposits.
Tertiary.			Probable on North-Eastern Coast of Zululand.		
Secondary.	Cretaceous.	Upper Cretaceous.	Umtamvuma Beds, South-East Coast Natal.: Zone of Ammonites Gardeni. Gasteropoda Bed. Ammonite Bed. Trigonia Bed. Sandstone with fossil-wood. The Bluff, Durban. (?) Littoral of Zululand.		
		Lower Cretaceous.		Uitenhage Beds.	
	Jurassic.	Upper Jurassic.		Enon Conglomerates; Heidelberg, Riversdale, Mossel Bay, Olifants River, Breede River.	
	Triassic.	Upper Karoo.	Plateau Basalts, top of Drakensberg Range. Cave Sandstones, Drakensberg Range. Red Beds, Drakensberg Range. Stormberg Series, Drakensberg Range. Beaufort Beds, on 2nd Plateau, West of Pietermaritzburg.	Plateau Basalts. Cave Sandstones, Stormberg. Red Beds, Stormberg. Stormberg Series. Beaufort Beds.	
Palæozoic.	Permo-Carboniferous.	Lower Karoo.	Ecca Series: Upper, Coal-bearing Sandstone and Shales. Lower, Shales (glacial).	Ecca Series.	Ecca Series; Coal-bearing at Middleburg and Vereenigin.
			Ecca Glacial Conglomerate.	Ecca (Dwyka) Glacial Conglomerate.	Ecca, Glacial Conglomerate.
	Carboniferous. Devonian. Silurian.		Table Mountain Sandstones.	Witteberg Series. Bokkeveld Series. Table Mountain Sandstones.	
		Upper Transvaal.			Magaliesberg and Gatsrand Series. Dolomite Series. Black Reef and Klipriversberg Amygdaloids.
		Lower Transvaal.	Hospital Hill Series; (Nkandhla District and Umfolosi River, south of Ulundi, Zululand.) Barberton Series of Swaziland.		Witwatersrand Series. Hospital Hill Series. Barberton Series of Swaziland.
			Intrusive Granites. Fundamental Granites with Gneisses and Schists.	Malmesbury Beds (correlation with Transvaal series unknown). Intrusive Granites.	Intrusive Granites Fundamental Granites with Gneisses and Schists.

(The Black Lines show Unconformities.)

possibility of obtaining artesian or sub-artesian water by boring or sinking in various districts of the Colony, and particularly in the neighbourhood of the city. The pre-eminent importance of having the necessary geological knowledge on this subject available to the public, so as to enable people to form an intelligent conclusion as to whether underground waters are likely to occur in rocks of a certain locality or not, together with the probable condition of these waters, if present, as regards their utility for domestic purposes from a public health point of view, was very apparent to me during the war, when epidemics of enteric fever, &c., were of such frequent occurrence. That many of these diseases are to be attributable to the use of a water-supply contaminated by surface pollution is a well-recognised fact, while it is also equally apparent that in permanent camps and hospital areas, where there is no thorough system of water drainage (which was a remarkably common state of affairs in South Africa), the presence of cesspits and a defective method of disposal of the sewage afford a wonderfully advantageous source for the distribution of disease germs in the subsoils, alluvial deposits, and even in the rocks, which are all vehicles, not only for the distribution of surface pollution but also for the supply of underground waters in wells and sometimes artesian water flows, when the source of the latter is at no great depth from the surface.

One of the chief geological conditions under which artesian water occurs, is the presence of permeable and impermeable strata, alternating more or less horizontally over an extended area. The water soaks into the permeable beds at their outcrops around the periphery of the basin, and it is kept there under increased pressure owing to the presence of impermeable beds overlying it and the weight of the superincumbent strata. Immediately the water-bearing permeable stratum is tapped by boring through the overlying impermeable strata, the pressure is relieved and the water rushes to the surface as an artesian well. Where the pressure is not sufficient to force the water over the surface, it is sub-artesian. There are other geological conditions under which artesian water frequently occurs. In the case of a vertical or inclined dyke of intrusive rock, traversing horizontal beds or strata dipping towards the dyke, there is often a chance that the presence of the dyke has acted as a natural dam to the underground flow of the water which has become packed in the underlying strata in the vicinity of the dyke, and that this can be tapped by boring. In very many cases this condition of things can be recognised from the geological evidences on the surface, and it is probable that in our country here, where there are so many intrusive basaltic dykes among strata of all ages, this occurrence of artesian water is much more common than is usually supposed, and it is exceedingly likely that in many cases this geological formation is the cause of origin of quite a number of our springs.

Both of these geological conditions, necessary for the presence of artesian water, are of common occurrence in South Africa. The first is typical of the great inland plains of the Karoo and the high plateaux of Natal; while the second occurs with great frequency almost everywhere where igneous intrusions have taken place throughout South Africa. Although one or other of these conditions is essential to the presence of artesian water, it does not necessarily follow that wherever they occur artesian water will also be found. Wherever excessive denudation has taken place, particularly among horizontal strata, the underground waters have thereby been tapped, and escape by means of the springs which have been laid bare over the denuded area. On a large scale this may be made intelligible by instancing the Natal slopes of the Drakensberg Range. The whole series of Karoo beds, some thousands of feet in thickness, consisting of permeable sandstones and impervious shales, which form the high plateau of the Orange River Colony, have been eroded through by denudation, and are exposed in section on the slopes of the Drakensberg, facing Natal. It is quite evident that the innumerable springs which feed our Natal rivers and creeks on the slopes of the Berg, must drain enormous quantities of water from the strata underlying the high plateau; so that on the plateau, in the immediate vicinity of the edge of the range, large supplies of artesian water could not be expected to be obtained by boring except under exceptional circumstances. To give an example nearer home, we have, in the neighbourhood of Pietermaritzburg, exactly similar geological conditions; that is to say, the horizontally bedded Ecca or Lower Karoo Series of shales and sandstones, forming the Town Hill and the country to the ~~east~~ of the city, as far as Thornville, where S the glacial Ecca Conglomerate appears below the sedimentary Ecca Series. Here, however, we have on a small scale the same physical geological conditions as occur on the Natal side of the Drakensberg Range, namely, the fact that the denudation which has produced the plateau of the Town Hill has cut through the whole series of Ecca beds to the basal glacial conglomerates exposed near Thornville and Baynes' Drift, and thereby has tapped in all the permeable beds of the series the permanent water, which now flows away in many of our superficial creeks which are fed by springs.

An exactly parallel case, although on a much larger scale, occurs in Cape Colony, where we have, for instance, in the neighbourhood of East London, large developments of the Ecca Series. Among these, boring for water has resulted in very poor results as regards quantity. This has been due, no doubt, to the same geological cause mentioned above, the denudation by the superficial streams, of the exposed Ecca Series from the high ground to the sea level, thus allowing of the escape to the surface, of the water, from the rocks of the Ecca Series. To the north-east, in the old colony, on the extensive Karoo plains, where the rocks are exactly the same in age (Ecca), constitution, and geological arrangement, but where the denudation has not locally cut very deeply into the series, they are abundantly water bearing, as is shown by the number of good wells, which are of frequent occurrence over the Karoo area. In this latter position the water is held in the rocks because it has not the facilities for escaping to the surface, by means of the sections of the series produced by excessive denudation. It is, therefore, tapped when the rocks are bored or sunk into.

The periodic flooding of our rivers and creeks is usually entirely due to superficial rains and thunderstorms; while in those rivers whose sources reach the Drakensberg watershed, a good deal of their water, in the early spring, is derived from the melting of the winter snows which often cover that range for weeks at a time. In the majority of cases, however, where our rivers and creeks are of a permanent character, the chief bulk of their water is derived from springs, which result from the accumulation of the superficial waters, which have soaked into the rocks below, instead of having been carried off as surface water by the rivers and creeks. Springs are exceedingly common in almost all our geological formations in most parts of the country. When present they form the natural drainage of the underground water, which therefore escapes by them, instead of being stored up to form artesian water. The presence of springs in large numbers in any district where the geological conditions are otherwise favourable to the presence of artesian water, is therefore against the probabilities of obtaining an artesian supply of any consequence.

It is therefore evident from the foregoing that, taking the broad physical geological facts, the chances of tapping large artesian or even sub-artesian water supplies in the district of the capital are not of a promising character. In the immediate neighbourhood, we have also to deal with the fact that the glacial Ecca Conglomerate has everywhere in South Africa proved itself to be a rock which rarely or never carries abundance of water, while the [redacted] Ecca Shales overlying it are so jointed and of such a clayey nature that they also do not carry any quantities of underground waters. Most of the springs along the range of the Town Hill have their exit from a higher horizon, from among the permeable sandstones at the top of the Ecca Series. The only position in which a large supply of water could be expected among the shales would be in the case before mentioned, where a vertical or inclined volcanic dyke had intruded the shales in such a way that it had formed a natural dam below ground, which prevented the escape of the waters soaking through the shales. In many positions, however, small household supplies may be obtained by sinking in the shales, but as a rule it is quite a mistake to excavate at the point of exit of a spring to any depth, with the intention of obtaining a larger supply somewhere below. In almost all cases the water forming the source of the spring is not in a stable condition filling a cavity, but is in a state of flow through the shales, and therefore, as it uses certain cracks and joints in the shales as its vehicle of flow, the mere fact of excavating may open up some new lines of flow for the water, which then disappears entirely. In many of the creeks and river valleys which have been eroded in the Ecca Shales, and have at the present time considerable depths of alluvial deposits of gravels and clays, underground waters are often abundant. These are usually the surface creek or river waters, or a portion of them finding a flowage channel through the gravels below. From such a source a fairly large well supply may be obtained, but it is very liable to pollution from surface drainage. It is usually present flowing through the lower levels of the gravels resting immediately on the shales, although occasionally it occurs at higher levels in the gravels. In most cases it is best to be content with this supply, because it has commonly been found that, on sinking into the shales below the gravels, the water, or a large portion of it, has disappeared into the deeper portions of the shales. This is quite easily explained by the fact that during the erosion of the valley through the shales and the deposition of the gravels the actual valley surface of the shales has become decomposed, softened, and saturated with water, while the joints in this portion of the shales have been naturally puddled by the finer material finding its way downwards with the water soakage. There is, therefore, an impermeable layer of decomposed shale, which allows of the flow over it of the water through the gravels, but which, when once broken by sinking, permits the water to soak into the deeper joints of the shale, and therefore pass away.

In the formations older than the Karoo Series—that is, below the glacial Ecca Conglomerate—the presence of artesian water is problematical, but in all of them small local water supplies are likely to be obtained, if the site for sinking is judiciously chosen.

Wherever the Table Mountain Sandstones appear at the surface, forming the bold, precipitous krantzes like Table Mountain, to the SSE ~~north-east~~ of Pietermaritzburg, and those of the sub-coastal area, from near the Tugela river mouth, to that of St. John's river, springs are exceedingly common, emerging from the much jointed and thin bedded sandstones of that formation. Wherever these sandstones are present over an extensive area, like the Noodsberg district, they are of a most porous character, and readily absorb large quantities of water. In many localities good supplies of water have been obtained from this series of rocks, but in most cases the local occurrence of the formation and the geological and physical conditions under which the beds occur must be taken into account in the selection of the well or boring site.

In all our granitic and metamorphic areas the country is exceedingly well watered; even during the late drought this must have been very apparent to any one who did much travelling over these areas.

As a storage for underground waters, granites occur in two geological conditions: in the hard undecomposed state, and in the superficial decomposed condition. In the case of the former, well-sinking would be of a very expensive character, while the amount of water likely to be obtained within a reasonable depth from the surface would probably be small. In the case of the latter, where the decomposition of the hard crystalline granite has produced a soft kaolinised quartzose deposit which often extends to the depth of 200 feet from the surface, the occurrence of a water-supply is not at all infrequent. These decomposed masses are most irregular in form on the surface of the undecomposed crystalline granite, and if they could be washed out, the hollows left, would form a wonderful series of caverns. The ultimate result of this decomposition is sometimes seen at the surface. An instance is reproduced from a photograph, in my first Report on Plate XII., where the decomposed granitic material has gradually been washed away, leaving the undecomposed kernels of granite, which are of enormous size, supporting each other on the hillside. Where such areas of decomposed granite occur *in situ*, they are saturated with water, and it is no uncommon thing, in boring or sinking, to come upon a natural basin formed of the undecomposed crystalline granite and filled with the superficial decomposed material, containing abundance of water. Unfortunately there are usually few evidences at the surface of the presence of such basins, which have frequently been the source of a water-supply sufficient to provide a small town with good water.

The quality of underground waters largely depends upon the nature of the rocks among which they occur. Water from a series of beds among which limestones or gypsum are abundant will contain a large percentage of calcareous matter in solution, forming a hard water. That obtained from among coal-bearing strata usually contains sulphur, and is generally ferruginous from the presence of so much pyrites in these rocks. The same is the case in all highly mineralised rocks, such as the metamorphic and plutonic rocks, which contain ores of the heavier metals. This is particularly seen where waters emerging as drainage from mineral mines, both old and new, have become charged with salts in solution or suspended mineral matter, from passing through the rocks containing the ores of lead, copper, &c. Such waters are deleterious not only to human beings but also to stock. The presence of some mineral salts in a water often proves a deception to persons ignorant of the following fact—that their presence in the water has precipitated all the mechanical impurities, and the water is usually perfectly clear, but thereby more dangerous than a muddy water would generally be. In most of our spring, well, and surface waters, practically over the whole of Natal and Zululand, the percentage of lime is not nearly what it should be in a wholesome water supply. This is due to the fact that, with the exception of the small area on the coast of Zululand and southern Natal where calcareous rocks occur, the formations forming the surface geology contain little or no lime-bearing rocks. There are a few isolated exceptions, of thin limestone beds, among the Ecca Series, and in a few granitic areas, lime is derived by the water from the decomposition of the felspars in these rocks.

In almost all cases, even in the form of artesian water, held under enormous pressure in the permeable strata in which it exists, there is a distinct flowage of the water in a permanent direction through the rocks. This has been noticed in many Queensland bores where the general trend of the flowage was northward towards the Gulf of Carpentaria, where the water-bearing strata dip under the sea. This movement of the waters underground helps to keep it generally in a more or less good condition, but sometimes, especially near the surface, it would be inclined to be a source of pollution by conveying along with it infected matter of a kind dangerous to health. It is not at all an uncommon thing to find, as has frequently been done in the central pastoral plains of Australia, in close proximity to each other, flows of underground waters, the one fresh and good and the other too salt for use. The saltness has been due to the passage of the water through beds of marine origin from which it has taken up the salt. In Natal and Zululand there are few districts where we have strata of marine origin, and these are confined to the coastal area where the marine Upper Cretaceous Series are locally developed. In the Port Elizabeth district of Cape Colony we have a similar case, where the superficial formation consists of the Uitenhage Series (Lower Cretaceous), which is of marine origin. When water is tapped in these beds it is usually brackish. To obtain fresh water in such a position it would usually be necessary to go through this formation to the rocks below.

As all underground waters are originally supplied from the rain, snow, and dew, before they get into the rocks, they have to soak through the soils, and whatever alluvial covering may be present over the outcrops of the rocks below. It necessarily follows that, in their passage through the soils and alluvial deposits, which usually contain large quantities of soluble salts, these are extracted from the soil, to its detriment, and carried into the underground water-supply; while a considerable amount of the deleterious matter which is so common on superficial deposits, is also carried along with it, often to the detriment of the people who use that water-supply. In almost every township in the Colony we have glaring instances of the latter method of pollution. Where well water, or rain water, stored in a tank in proximity to the house, is used for domestic purposes, the presence of cess-pits are the most dangerous to health of all the known methods of getting rid of sewage. The reason is so simple, and it is a geological one, that it hardly needs repeating. Nature, as usual, has provided the most efficient scavenger, in the surface mould, the soil where it is present, the existence of which has been due to the amount of vegetable and mineral matter it has had the opportunity of assimilating; and thereby has become the most efficient filter possible, to protect the underground waters from pollution by local surface drainage which usually conveys many disease germs. The formation of the cess-pit always breaks through this natural soil-filter, with the result that local underground waters are immediately and often permanently contaminated, while it is quite a common thing to find that the individual or family is drawing water for household and domestic purposes from a well in the same little compound, and it is frequently the case that the cess-pit is situated higher up the slope than the well.

The principle involved in the above has a much wider application than at first sight would appear. All porous strata, consisting of sands, gravels, sandstones, conglomerates, &c., are usually more or less water-bearing. In the beds of all river and creek valleys, old alluvial gravels frequently occur, forming flats and filling in the ancient channels and inequalities, formed in the bed rock, by the erosive action of the river or creek. Frequently these gravels are a vehicle for the conveyance of underground waters from the upper reaches of the river, and therefore such waters will convey any contamination which may be present in or get washed into the waters in the upper portions of the valley. A local case in point is quite typical. Wells have been repeatedly sunk on the alluvial flat immediately to the north of the city, and the water therefrom used, not only for domestic but for public purposes. This well water has been obtained from the alluvial gravels (overlying the Ecca Shales), which are the result of the erosion, by the present creek, of the rocks (shales, basalts, &c.) which formerly occupied the site of the valley higher up, and have been deposited in the inequalities of the bottom of the valley, as the undestroyed and untravelled residue of these rocks. During the passage of the water through these gravels the latter have, to a certain extent, acted as a filter, but by no means an efficient one. Immediately below the Botanic Gardens, week in week out, a very large proportion of the material dirty linen of the city is washed in the superficial waters of the creek, which are, almost wholly, the chief source of supply of the waters in the alluvial gravels, used from the wells about a quarter of a mile lower down the valley. After every severe thunderstorm the waters contained in these gravels naturally become contaminated by the enormous quantities of surface pollution, which is washed into the creek from the streets and hillsides within its watershed. If such surface pollution is allowed, practically within the limits of the city, it seems to me that there is no wonder that epidemics occur as frequently as they do.

From an agricultural point of view, a knowledge of the geological origin and composition of the soils of the Colony is of importance in assisting the farmer to a better understanding as to the best chemical necessities which he requires to add to various soils in order to obtain the best crop-results from them. Nature has, by its unaided physical processes, provided in most countries areas of extraordinarily rich and fertile soils, like the wheat-growing districts of Manitoba and the fruit-growing regions of California, and many localities in other countries which need not here be mentioned. These have been taken advantage of by the agricultural settlers, who in many cases, through ignorance of the principles which govern the formation of soils and their treatment agriculturally, or through utter disregard of these principles, crop off the same soil until they have extracted so large a proportion of the chemical constituents that there are not sufficient, in the soil without replacement, to grow anything but very inferior products. This is, unfortunately, a much too common occurrence in this country. No doubt the educated, better-class farmer takes an intelligent interest in the soils on his farm, and to a certain extent manures them ; but the large majority pay little or no attention to this phase of farming, particularly the kaffir and the coolie, the latter being by far the greatest sinner in this respect. One has only to take a tour through the northern coastal district of Natal to observe, particularly if he knew the country five or six years ago, how the coolie invasion has been allowed not only to destroy the natural timber, but they have proceeded further and exhausted the local patches of good soil to such an extent that in a very few years much of this country will be useless for agricultural purposes without large expenditure in the way of manures, &c.

The almost entire absence of calcareous beds among the various formations of this country, and the limited areas occupied by those which do contain calcareous rocks, has produced in almost every district a deficiency of lime as a soil constituent. The few districts occupied by rocks of a calcareous composition are: the littoral of Zululand, where a development of Upper Cretaceous beds occur; the neighbourhood of Port Shepstone in Natal, where a metamorphic limestone (marble) outcrops for some distance up the Umzimkulu river. From one or two places in the Tugela river valley to the north-east of Greytown metamorphic limestones are also reported. As is shown further on in this report, the deficiency of lime among the sedimentary rocks does not affect the soils, derived locally from crystalline rocks like granite, basalt, &c., which furnish from their lime-bearing minerals a varying percentage of lime to the soils.

The soils of Natal and South Africa generally are almost entirely of local origin, and differ in this respect from those which are better known in North America and Europe. The latter have, to a very large extent, been derived from the degradation of the glacial boulder clay, &c., which are the relics of the Pleistocene glacial epoch, and therefore consist largely of the *débris* of rocks which has been transported often long distances from their parent source. In South Africa we have no evidences of a geologically recent glacial epoch such as occurred in Pleistocene times in the northern hemisphere and even in Australia.[*] In a short paper in the *Geological Magazine* the late Dr. Exton[†] describes large quantities of rounded and polished boulders which occur scattered over the country to the south of Ladysmith—that area, the possession of which was so stubbornly contested during the early part of the late war. He attributes the occurrence of these boulders to a Pleistocene glacial epoch, and supposes them to be erratics. I have lately been over this country, and have found that there is not the slightest doubt that in almost all cases the boulders are of local origin—in fact, that they are merely basaltic boulders left by the denudation of the igneous rocks which are so common in this neighbourhood, the geology of which is interesting. As Mr. E. J. Dunn pointed out years ago, the shales around Ladysmith belong to the Lower Ecca Series, which have been intruded by basaltic rocks to such an extent that the main physical features of the district are marked out by the presence of these slowly decomposing basaltic sills and dykes, which form the krantzes and flat-topped hills, and produced the kopjes and the boulders strewn over the hill-slopes which proved of such utility in the defence of this district during the war. Although at the present time the major portion of the rocks of this district are igneous, this is not a volcanic region in the same sense that, for instance, the Puy-de-Dôme, in France, is a volcanic region. The presence of the volcanic rocks in the latter locality is due to geologically recent eruptions of these rocks on the surface; while, in the case of the district to the south of Ladysmith the occurrence of so many outcrops of basaltic rock is due to the fact that the basalts which were intruded among the shales have subsequently only been exposed at the present surface, owing to the erosion and denudation of the sedimentary and other rocks which covered them, by the action of the superficial waters.

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[*] David, T. W. E., Presidential Address, *Austr. Ass. Advancement of Science*, p. 35. Brisbane, 1895.

[†] *Geol. Mag.*, vol. viii. pp. 509 and 549, 1901.

Under these circumstances it will be found that most of our soils have a local origin, except in the case of alluvial flats, formed in the courses of our rivers, which are, however, not of very frequent occurrence, where the bulk of the material has been transported by the waters of the streams from positions higher up the valley. In many districts, particularly in the interior, this has not made much difference to the transported soils, because over immense areas the general composition of the rocks is very uniform, as exemplified by the wide distribution in south-western Natal of the Ecca Shales with their intruded basaltic rocks.

In this country, where basaltic rocks in the form of sills and dykes are of such universal distribution, there is no lack of the necessary ferruginous constituent in most soils. In fact, the difficulty with soils derived, ***in situ***, from the decomposition of basaltic rocks is the presence of too much iron in the form of the protoxide FeO, which in this form is prejudicial to plant life. This is usually remedied, however, by hastening the oxidation of the protoxide into the sesquioxide Fe_2O_3, which is harmless, by increasing the supply of oxygen, by ploughing, burning, or adding caustic lime. The original source of the iron in basalts is from the minerals magnetite, ilmenite, &c., the iron in which, upon the decomposition of the rock, ultimately passes into the soil and gives it that chocolate colour which is so conspicuous a feature in the scenery of most districts. To show the effect of basaltic rocks upon soils, cases have been known where, on unreclaimed ground in Britain, the presence of a basaltic dyke made itself apparent by the fact that its course could be identified by the greater strength and greenness of the grass. I have seen instances of this in the Stormberg district of Cape Colony, where these dykes are of extremely common occurrence, cutting the coal-bearing sandstones in all directions. For pasturage no better soil can be got than that derived from basalts, so long as sufficient water can be kept on it. The odd member of the British Isles acquires its pseudonym of "Emerald Isle" from the fact that the prevalence of basaltic rocks in most parts of Ireland have produced soils of great fertility for pasturage. In New South Wales and Victoria, Australia, the occurrence of Tertiary basaltic lava sheets have had an enormous effect on the productiveness of the soil in the districts in which they are present. Advantage is always taken by the settlers, of the alluvial flats or other areas composed chiefly of basaltic soil for agricultural purposes, and immense crops of lucerne, &c., are taken off these where they can be properly watered, The reason why soils derived from basaltic rocks should be more or less fertile is that the minerals which composed them, felspar, augite, magnetite, &c., contain a large percentage of iron, magnesia, lime, and often potash from the felspar. It is very frequently the case, however, that when such a soil has first been broken up a deficiency in lime has been observed; but this is merely due to the fact that the top portions of the soil has had the lime bleached out of it. This can usually be remedied by a single dressing of artificial lime, as the lime from the decomposed stratum below gradually finds its way to the surface soil.

In metamorphic and granitic areas, where the rocks are more or less crystalline, and contain chiefly quartz, felspar, hornblende, mica, with many other accessory minerals, the soils resulting from the degradation of the former (gneisses, schists, &c.) are usually of a decidedly clayey nature, while those derived from the latter are of a more sandy character, but still containing a large amount of clayey material from the decomposition of the felspar. The chemical constituents of the ordinary minerals in these rocks, potash, alumina, silica, lime, magnesia, &c., are such as are necessary to the formation of a good soil. The reason why granitic areas are not, except in rare cases, used to any great extent for agricultural purposes is a physical geological one. Surface denudation of these rocks generally produces a most rugged country, which is always against the preservation of the soils for agricultural use; but where it happens that any extensive area of moderate slope is covered with granitic soil, the quality of the soil is beyond dispute. As a local example, there is the area in Central Zululand, known as Proviso B, in the neighbourhood of Melmoth. This area consists of granitic and metamorphic rocks, and particularly in the higher portions the soil is of a most productive character. The same is the case on the more level portions of the valleys in the Inchanga and Inanda districts of Natal, where a somewhat similar granitic soil occurs. The high angle of the slopes in rugged granitic country accelerates the drainage from the soils, where they are present, of all the alkalies in solution, as well as the other soluble chemical ingredients, which are necessary to the formation of a good soil. In some parts of the world granitic soils are of extreme richness from the presence in the granite of apatite, a mineral which is a natural phosphate.

Among the granites and metamorphic gneisses and schists of this country, besides the ordinary ferruginous minerals, titaniferous iron, magnetite, &c., the decomposition of hornblende, which is a very common mineral in these rocks, furnishes a considerable amount of iron to soils formed from them. The resulting red colour is quite a characteristic feature in many of the metamorphic areas of the Colony. This colouration of the soil can quite readily be mistaken for evidence of the presence below of basaltic rocks, intrusive in the granites or metamorphic series, but it is a curious fact that on almost all the present exposures of these rocks it is rare to come across basaltic dykes, although in the later sedimentary formations the latter are so common.

When, however, basaltic rocks do occur in association with granites, the resulting soil is of a remarkably fertile character.

The areas in which a sandy soil has been derived from the Table Mountain Sandstones are of no great extent, owing to the somewhat limited outcrops of this formation in Natal. They are, however, rather important, as it is on them that our chief plantations of wattles are grown, as instanced by the Noodsberg district to the north-east of Pietermaritzburg. This soil is almost entirely composed of silicious grains, with the admixture of a certain amount of clayey material, derived, no doubt, from the degradation of the glacial Ecca Conglomerate and Shales which have locally overlain the Table Mountain Sandstones in many portions of this district, but which have subsequently been denuded away. The rich alluvial flats of the Umgeni river in the neighbourhood of Otto's Bluff and Table Mountain are the result of a good mixture of Table Mountain Sandstone *débris* and clayey material from the Ecca Series with the necessary decomposed vegetable matter. Another district in Natal may be cited whose soils are exactly similar in their geological constitution to those of the Noodsberg. In the Mid Ilovo district we have the Table Mountain Sandstone Series well developed and furnishing a sandy soil, which has been supplied with clayey material from the degradation of the Ecca Series, outliers of the lower portions of which still occur in isolated positions over the district. These, with the assistance of the local intrusions of basalt, have produced a soil which is of a most productive character, and as all the districts composed of Table Mountain Sandstones are remarkably well watered, chiefly by springs, the conditions are such, that with proper, scientific, up-to-date methods of farming, and the necessary facilities for transport of products to a market, these areas are certain, in the future, to prove most desirable agricultural country, unless they are allowed to fall into the hands of coolies or others who have no conscience as regards farming. Some portions of central Zululand possess soils similar to these. In the neighbourhood of Melmoth wattles grow well on a soil resulting chiefly from the decomposition of Table Mountain Sandstones. On soils of exactly similar geological origin in the Paarl and Stellenbosch districts of Cape Colony, an important industry has been developed in fruit-growing. This has been carried on to such an extent that now a regular export of peaches, &c., &c., is taking place from these districts to Europe, with great profit to the enterprising individuals who have been persistent enough to carry it through.

By far the larger portion of Natal is occupied by rocks consisting of shales, with occasional sandstones. These form the Ecca and Beaufort Series. There is a considerable difference in the prevailing colour of the shales belonging to the two series. Although purplish shales do occur rarely among the Eccas, they are generally grey or black, while among the Beaufort Series they are almost entirely of a more or less purple colour. Both series are freely intruded by basaltic rocks, the degradation of which is the redeeming feature in the production of soils from these rocks which are possible for agriculture. Without the basaltic intrusions the resulting soils would be of the poorest quality. In almost all cases, however, the amount of lime supplied to the soils through the decomposition of the lime-bearing minerals in the basaltic rock is not sufficient, and it is usually necessary to add this soil-ingredient artificially if the best crops are desired to be reaped. In the upper coal-bearing portion of the Ecca Series and also among the Beaufort Beds, sandstones are of common occurrence, and they furnish, in such localities as they are developed, a large amount of sandy material which has a considerable mechanical value in the formation of the soil. Most of the interior of Natal, between the second plateau and the Drakensberg Range, consisting of soils derived from these formations, forms the best agricultural area in the country. In many districts it is merely a want of enterprise and agricultural knowledge which prevents the Natal farmer from working his land to the best advantage, by local irrigation, proper manuring, and attention to the recognised principles of scientific farming.

While in Cape Colony in the winter of 1902 (see Report on the Stormberg Coal Measures to the West of Molteno, Cape Colony, at page 139), I had an opportunity of studying the development of the Stormberg series, which is represented only in the higher portions of the southern and eastern slopes of the Drakensberg Range in Cape Colony, Griqualand East, and Natal.

Reports have been frequent of the presence of outcrops of coal, highly bituminous and carbonaceous shales, from many localities along the eastern escarpment of the Drakensberg Range. In a few of these localities a little prospecting has been carried on, but no developments of any kind have resulted. This has probably been due to the distance of these outcrops from the existing railways, and therefore the necessarily large cost of transport, which would at present prevent any competition with the Dundee and Newcastle coal-fields. In the Natal Stormberg Series, shales containing a small percentage of oil have been cursorily investigated in the neighbourhood of the source of the Lutin river, to the west of Pietermaritzburg, but so far nothing has come of it. The beds associated with the oil-bearing shales of the Lutin river are exceedingly fossiliferous, and although they are of a most brittle and fragile character, many of the plant remains have been identified from them as belonging to genera and species which are characteristic of the coal-bearing portion of the Stormberg Series, which is best known in the Molteno and Indwe districts of the old Colony. These fossils consist chiefly of *Thinnfeldia odontopteroides* Morr., *Pterophyllum*, &c.

This series of Stormberg coal-bearing beds on the Natal escarpment of the Drakensberg are separated from the coal-bearing series of the Dundee and Newcastle coal-fields by a considerable thickness of variously coloured shales, &c., which can probably be correlated with the Beaufort Beds of Cape Colony. This stratigraphical fact, necessarily places the strata of the latter coal-fields on a much lower horizon than the Stormberg Series of the Drakensberg. Elsewhere in this Report it is shown that they belong to the Ecca or

Permo-Carboniferous period. So far as my investigations in Natal have gone there seems to be no break in the succession, from the Ecca Shales right up to the top of the Stormberg Series, as I have not met with any evidences of unconformability. Few fossils have been discovered locally, in the Beaufort or intervening series, with the exception of a few Reptilian remains such as isolated Dicynodont bones.

As was shown in my first Report, the Ecca coal-bearing series of the north-east coast of Natal and of Zululand are characterised by a fossil flora completely different from that of the Stormberg Series. In the former, the prevailing plant remains are *Glossopteris* and *Phyllotheca,* while in the rocks of the latter series the genera *Thinnfeldia, Pterophyllum,* &c., predominate. In the coal-fields of the eastern coast of Australia a similar distribution, in time, of the fossil flora occurs, as pointed out years ago by Mr. E. J. Dunn, when the Cape Government published his Reports, which are the most valuable of the early accounts of the geology of the southern portions of South Africa. He stated that in the Australian coal-producing strata, the coal occurs on two different horizons, and that these are characterised by the fact that the Permo-Carboniferous horizon, overlying the glacial conglomerate yields fossil plants consisting chiefly of *Glossopteris,* &c.; while the overlying Hawkesbury Series contains specimens of *Thinnfeldia* in great abundance. The analogy to these South African coal-producing series is still further borne out in the southern hemisphere by the geological occurrence of the coals in India on geologically similar horizons; and to a certain extent, although as yet our knowledge is imperfect, by the presence, in South America, of a palæontologically similar Karoo Series, among which impure coals have been recorded.

Lately during a flying visit to Newcastle, the first opportunity I have had of visiting this district, since the war broke out, the stratigraphical evidence pointed distinctly to the fact that the coal-bearing series of this neighbourhood are of Ecca age; while the fossil flora, chiefly species of *Glossopteris,* points to a similar conclusion. For the same reasons we have, in Natal, the productive coal-measures of Dundee and Newcastle districts, the unproductive coal-bearing rocks of the north coast, Estcourt, York and Greytown districts, all belonging to the same series of rocks; while all the coal-bearing strata of Zululand also belong to the same upper portion of the Ecca Series. Besides these, however, we have, on the slopes of the Drakensberg Range, a coal-bearing series of strata, whose fossil flora proves it to be of Stormberg age, which is considerably younger than the Ecca coal-bearing series, and probably belongs to some part of the Triassic period. Little or no serious prospecting for coal has yet been done, among this series of rocks, from Natal, through Griqualand East to the Stormberg district of Cape Colony.

The Ecca coal-bearing series of the east coast presents the peculiarity that in the various basins in which it occurs, the presence of coal, productive or otherwise, is most erratic. In every case, however, where coal is present, it is developed only in the upper portion of the

Ecca Series. No occurrence has yet come to my knowledge of the presence of coal, even of poor quality, in the lower black and light-coloured shales of this series. Again, even among the sandstones of the Upper Eccas, there are localities where the sandstones have been developed to such an extent that even carbonaceous shales are of rare occurrence. In the upper portion of the Town Hill, Pietermaritzburg, N-W & W and to the ~~westward~~ by Zwartkop towards Byrnetown, this is the case. On the same horizon, on the north coast, thin impure coals occur, but not of sufficient thickness or quality to be of any value. On the other hand, in the Dundee and Newcastle districts we have coal-seams of workable thickness and excellent quality as well as, on different, and practically the same horizon, coal-seams of poor quality and most irregular development.

As indicated thirty years ago by Mr. E. J. Dunn, the north-easterly extension of the Stormberg coal-bearing series occupies large areas in Griqualand East, Basutoland, and the Orange River Colony. Although in isolated localities in these areas coal is known to occur, no systematic attempt has been made by the various governments to obtain an authentic geological knowledge as to the presence, mode of occurrence, distribution, and coal-producing capabilities of this formation.

In the northern part of the Transkei, where the Stormberg Series is largely developed, outcrops of coal and carbonaceous shales are of frequent occurrence, and as the strata are, almost everywhere, perfectly horizontal, the working of such productive coal-seams, as occur, would be of a most economical character. At present, the road transport would, however, kill the industry. In the neighbourhood of Cala, Ingcobo, Ugie, and Maclear, reports of the occurrence of coal of good quality exist. In view of the fact that within a few years railway communication will be established between Natal, through Griqualand East or Pondoland, and the East London railway line in Cape Colony, through a portion of the Transkei, it behoves the various governments to have a thorough geological investigation into all these areas, immediately flanking the Drakensberg Range to the east, from the Stormberg district of Cape Colony right into Northern Natal where the rocks of the Biggarsberg connects our Ecca Coal-Measures with those of the Stormberg Series. On the western side of the Drakensberg Range there must be in Basutoland, a considerable development of the coal-bearing Stormberg Series which is at present utterly unknown.

In conclusion, I desire to record my thanks to Mr. Robert Etheridge, Curator of the Sydney Museum, New South Wales, and to Professor A. C. Seward, Professor of Palæobotany, Cambridge University, England, for their papers on Natal fossils. I have also to thank my colleague, Mr. Claude Fuller, Government Entomologist, for his reproductions of the drawings of Plates IV. and V.

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FURTHER NOTES
ON THE
RECONNAISSANCE GEOLOGICAL SURVEY
OF
ZULULAND.

FURTHER NOTES ON THE RECONNAISSANCE GEOLOGICAL SURVEY OF ZULULAND.

As the western portion of the province was still subject to periodic raids by the Boers during 1901, and the early part of 1902, I had to confine this work chiefly to the more eastern parts of the country. In the last few months of the latter year, however, I was able to carry the general survey to the north-western border, where I had an opportunity of connecting my geological work with that done by Dr. Molengraaff, in 1897, in the Vryheid District, now of Natal. This was of advantage, as it is the first time I have had an opportunity of doing so, and thereby proving satisfactorily that certain formations in Natal can be correlated stratigraphically as well as palæontologically with those of a neighbouring State. This will, however, be dealt with more minutely further on in this Report.

There now remains the Nkandhla, Nqutu, and Nondweni Districts, and an area between the Black and White Umfolosi rivers, above their junction, still to be traversed in a general way. A good deal of the country visited in the two previous years, 1899 and 1900, has necessarily been traversed again; but this has been no disadvantage, as it has enabled me not only to make many corrections and additions to the geological boundaries on the sketch-map of Zululand, but has also added to the better understanding of the geology of the eastern portion of that country.

The large area to the south and west of Melmoth has also been examined and mapped geologically. This district, composed chiefly of granites with gneisses, schists and metamorphic rocks consisting of quartzites, jasperoid rocks, conglomerates, &c., is dealt with in a separate report further on. Considerable activity was once shown in the efforts to develop the gold-bearing quartz reefs, evidences of which were frequent among the older granites, gneisses, and schists. Even the horizontally bedded basement conglomerates of the Table Mountain Sandstones were mistaken for banket and largely prospected in this district, naturally with no result. Unfortunately none of the reefs which were opened up proved of a permanent character, and owing to the usual unbusinesslike and seemingly irresponsible prodigality of newly formed companies or syndicates, the remains of the batteries and other expensive machinery are still dotted over the district as evidence of previous mining energy. At the present time one or two parties are still prosecuting the search, but with little return. The granite and schistose rocks of this area persist to the south and west into the Nkandhla and Nondweni Districts, while to the westward on the borders of the Vryheid and Utrecht Districts they become covered with the metamorphic rocks of the Hospital Hill Series and the newer formations. They, however, again come to the surface in the north, where, in Swazieland, they are enormously developed.

During the last two seasons I have had the opportunity of traversing several new areas on the littoral, viz., across the southern end of St. Lucia Lake to Cape Vidal and the neighbouring coast for some miles to the south; from the northern coastal road to Foxon's Camp, to the coast some miles to the south of Sordwana Point; and as far north as Lake Sibayi. The general physical characters of the whole littoral area are much the same, uniformly flat or slightly undulating, with the principal river channels cut deeply into the subsoils, but rarely exposing the rocks underneath, which should prove generally, to be some portion of the upper division of the Cretaceous Formation, although there is a possibility that local developments of Tertiary rocks may occur. Many large areas, particularly in the northern portion, are covered with dense, native timber, which, however, rarely attains any great height, while the undergrowth is quite analogous to what is generally known in Australia as scrub, and frequently more impenetrable. To pass through such areas, unless on foot by the native tracks, a way has to be cut through the denser portions of the undergrowth and timber, to allow of the passage of waggons. In the south, around St. Lucia Lake, the country is usually open and plain-like, the irregularities of the surface being chiefly due to the presence of occasional areas, occupied by low, shifting sand-dunes, not permanently covered by vegetation. This, however, is not always the case. Around False Bay and the northern end of the lake there are large areas of dense timber and scrub, which afford admirable cover for game of all kinds, which abound in the reserve in this neighbourhood. To the north of the lake where the country is not occupied by timber and thick scrub, it is open, plain-like, and sandy, and many local areas, of considerable extent, are waterless, or only brackish water is obtainable. This open country is dotted over with isolated clumps of a species of palm, whose aerial stem is of the most limited description, from which the leaves, usually rising some yards in height, are developed successively in opposite directions from a central bud. They afford convenient shelter for a camp. The natives use the sap, which they obtain by tapping the root, just where it emerges from the soil, as a fermented beverage. Its effect seems to be a very bad one mentally, as they get dull and lethargic, and become incapable of undergoing any exertion, or appreciating an order sufficiently to execute it, without material assistance of a drastic character.

The permanent waters existing over this large littoral area are of three kinds—rivers, lakes and pans, and springs. Many of the pans are permanent, but during the rainy season and for some time afterwards, in February, March, and April, most of the inequalities of the surface become filled with superficial accumulations of rain-water which form what are called pans. Most of these smaller pans soon dry up, and only the larger ones and those fed from springs remain permanent throughout the year. Some of the permanent pans are brackish, while many of them are quite fresh and fit for use, although in most cases the water is of a light sherry colour, and tastes, even after boiling, of vegetable matter. Both the colour and taste are intensified after every rainfall. In most cases, even in those which are slightly brackish, the herbage growing in them is always green, and both cattle and horses prefer it to the ordinary veld grass.

The rivers of the littoral are the coastal portions of those which originally drain the southern part of Swazieland, the Vryheid and Utrecht Districts (the new Natal territory), which debouch from the elevated country of the interior on to these plains. The principal of these are the Usutu, Pongola, Mkuzi, Umfolosi, and Umhlatuzi. They all flow in a more or less easterly direction across the flat littoral. Besides these, there are numbers of smaller rivers, which have a local origin in Zululand. These are the Enseleni flowing into the western end of Lake Sibayi; the Manuan Creek into the north end of False Bay; the Hluhluwe and Enseleni, from the St. Lucia coal-field, into the southern end; with the Umpata flowing into the outlet of St. Lucia Lake. Many of the latter, together with the smaller and more local creeks, have their origin in springs. As a rule the large rivers do not present much difficulty to crossing with waggons, but in the case of the smaller local streams it is almost impossible to cross many of them for long distances, owing to the swampy and boggy nature of their valleys. In fact, in many of them a native cannot cross with safety except at a recognised, so-called drift, which usually consists of a log or a series of logs that have been heaved into the bog by successive generations of kaffirs. The presence of these swampy valleys is most annoying to the traveller, as it is impossible to cross them on horseback, and a waggon is out of the question, without heading the valley and rounding the spring.

The lakes are of all sizes, the three largest being Lake St. Lucia, Kosi Lake, and Lake Sibayi. These are disposed with their longer axes parallel to the coast, from which they are usually separated by a few miles of sand-dunes. The two former are connected with the sea by narrow channels, while the latter has no surface connection with it. In both the former cases the so-called channels, formed by the narrowing of the lakes, extend for a distance of about ten miles above the sea-opening. The direction of the channel of Kosi Lake is to the north-east, while that of St. Lucia is almost directly south. These two sea-openings, together with that of the Umhlatuzi river, further south, form the only examples of natural harbours on this coast, from Durban to Delagoa Bay. In their present natural state they are worthless for this purpose, as they are separated from the sea by moving sand-banks. As a rule, the configuration of these sand-banks is only altered by the action of the waves on their seaward aspect, but sometimes they are completely washed away or greatly altered by floods from the land side. These latter are, of course, only occasional occurrences, but nevertheless they form a large factor to be dealt with in the conversion of these bays into harbours. An example of this may be given here. Mr. J. Sanderson,[*] speaking of the floods of April, 1856, says: "I am farther informed that the mouth of St." "Lucia Bay itself, which I have laid down from a sketch by Mr." "William Rider, was much altered by the mass of water brought" "down by the Mkuzi in the month referred to. The principal" "outlet, I am told, is now where the 'sand-hill 100 feet high' is" "laid down, that sand-hill being almost entirely swept away, and a" "bank left between the old and the new mouths. In fact, all along" "the coast, lakes and pools are formed, which in freshets are" "frequently connected with each other and the various rivers" "adjacent; and circumstances, impossible to determine beforehand," "may cause an old channel to be closed up and a new one opened" "for the several streams. . . . Heavy rains bring down and deposit" "trunks of trees, reeds, and other *débris* on the sand-banks at one" "spot, and at another undermine them, and thus divert the mouth" "from point to point, often miles apart." It will be seen from the above example that during a single heavy flood the principal outlet was moved a considerable distance along the beach, and was formed by the removal of "a sandhill 100 feet high." The Mr. Rider mentioned in the above extract visited St. Lucia Bay in July, 1853, for the purpose of shooting sea cow (Hippopotamus). He gives the following interesting details concerning this bay. The entrance at the time of his visit was "about 50 feet across at low water, with 12 feet water" "at spring tide; the rise and fall being 4 feet 6 inches and time of" "high water at full and change at 4 o'clock." This particular bay differs from the others on this coast, in that it has been formed by the exit on the coast of the waters delivered by the Umfolosi river and St. Lucia Lake, the overflowing of the latter being due to the flooding of the Mkuzi and all the other rivers which flow into the lake. This means that St. Lucia Bay has to afford outlet for the drainage of an area comprising more than the half of Zululand and a very large proportion of the Vryheid and Utrecht districts. Any one who has seen the principal rivers in this drainage area—the Umfolosi, Mkuzi, even the Hluhluwe—when in ordinary flood, will appreciate what this would imply when the flood is to any extent above the normal and of long duration. The volume of water which would pass into the Bay under the above exceptional circumstances would be enormous. The low grade of the river beds, on the littoral, together with the physical water-carrying capacity of the lagoon and bay behind the coastal sand-banks, would allow of the accumulation of a certain amount of the flood waters until a limit of pressure was attained sufficient to counterbalance the outside surface sea pressure, and the material of the intervening sand-banks or dunes; the ordinary channel of exit being quite inadequate to carry off this superfluous body of water, the result would follow that, if the old channel could not, for physical geological reasons, be scoured out, to a depth sufficient to allow of the exit of the flood waters, another channel would be forced through the sand deposits in the neighbourhood of the old outlet. It is therefore not surprising to hear of an instance such as that quoted above, in reference to the sea outlet of this bay.

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[*] Journ. Roy. Geogr. Soc., vol. xxxii., p. 335, 1862.

Some of the lakes and lagoons are tidal or brackish, while even one of the largest, Lake Sibayi, is quite fresh. They all possess a fauna, of a kind which is sure to prove, when known, of a most interesting character, both zoologically and palæontologically. There is no doubt that most of the larger lakes have originally, before the elevation of the littoral into a land surface, been depressions in the sea floor, because in almost all cases we get outcrops of rocks, so far as I have seen, mostly Cretaceous, around their margins and in their neighbourhood. Their presence as lakes has certainly been accentuated by the surrounding superficial Pleistocene and Recent sands, which have subsequently been accumulated on the Cretaceous rocks since their elevation into a land surface. Although some of them have, evidently, always had a tidal connection with the sea, yet even their faunas must prove of interest and importance zoologically; while the fauna of a fresh-water lake like Sibayi, which has no apparent sea-outlet, and occurring, as it does, so close to the coast line, is sure to furnish zoological results of an important character. Here we have, geologically speaking, a comparatively recent elevation of the littoral on which these lakes occur, but, with regard to the height above sea-level, they do not occupy anything like the position which the Central African lakes, such as Tanganyika, &c., do, where the Molluscan fauna, at least, has been proved by Mr. Moore * to have its nearest allies among certain fossil molluscan forms belonging to the Jurassic Period; while in South America, Lake Titicaca, situated among the highest Andes, presents in its present fauna similar palæontological phenomena, in that the nearest allies to the fauna are of marine types.

Springs are of frequent occurrence over much of the littoral, and in most cases, where they occur of any strength, they form, as stated above, the origin of the minor streams. In no case have I yet come across a spring emerging at the surface directly from the bed-rock, except in the immediate vicinity of the sea-shore, where they often issue directly from the outcrops of the Cretaceous rocks. Away from the coast, in all cases they have forced their way to the surface through the superficial Pleistocene and Recent sands. Many of them are brackish, and in many of the poorly-watered districts they are of very small dimensions, and merely ooze out of the sand into a small hollow made by the natives, producing hardly sufficient to fill a bucket at one time. Notwithstanding this, where these small springs are permanent, there are frequently even two or three kaffir kraals in the near neighbourhood, whose water-supply for a considerable portion of the year is entirely derived from them.

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* "Tanganyika Problem."

The general surface alluvial deposits over this littoral area consist of sands. These have been derived originally from the sands of the sea-shore, which have gradually been blown inland, together with the sands and other deposits which were left on the old sea floor when it was raised into a land surface during post-Secondary times. Locally, however, this loose drift sand has been converted into a good porous soil by the natural admixture of vegetable matter and mineral *débris* brought down by the superficial waters, and distributed over certain areas. Just below the point where the northern coast road crosses the Umhlatuzi river a large swamp occurs, spreading over a considerable area of flat country. Wherever possible the neighbouring natives use this alluvial for cultivation. In many other localities on the littoral similar extensive areas occur, which, with proper drainage and a little attention to the first principles of irrigation, would prove most productive from an agricultural point of view. It is no uncommon thing to find in these littoral districts that the natives have green mealies practically the whole year round. If they, with their primitive methods of agriculture, and their limited wants as regards quantity, prove that the soil is so productive, surely with civilised ideas and modern agricultural appliances it stands to reason that this area could be made into an exceptionally productive portion of the colony. In districts where pans are of frequent occurrence peaty soil is present over large areas, as a result of the decay of the small scrub and vegetable growths which are common in such places. Such deposits could quite easily be used in other localities as local additions to poor soils.

Large areas of the littoral are occupied by shifting sand-dunes, which are of a most unproductive character. But this purely sandy soil, particularly around the margins of the fresh-water lakes, and even immediately to the inland side of the coastal range of sand-dunes, is largely used by the natives for the production of crops; while the cattle belonging to the kraals, which are often scattered in numbers in the latter position, feeding chiefly on the grass, &c., of the sand-dunes at the coast, are always remarkably fat and in good condition. Towards the end of the war a number of refugee Boers were allowed to treck from the interior through the western portion of Zululand and camp with large herds of diseased cattle, which at first died in large numbers, on a large flat some miles to the west of Port Durnford, just inland from the coastal sand-dunes. These people camped there with their cattle till the end of the war, and then returned westward to their homes, and no one would have believed that the cattle they possessed then were the same that they had brought with them. All the year round, even in the driest season, where the grass does grow over this coastal district, it is always green, and cattle always fatten upon it.

I believe it is the intention of the Government to shortly throw open a large portion of the littoral to white occupation. It has often been remarked, and even stated in public journals and lectures, that the Zululand littoral must be equally good for sugar growing to the coastal part of Natal. To a certain extent this is true. The climates of the two areas are practically identical, but a little warmer in the northern part of Zululand where the hill country is farther away from the coast and the latitude is a few degrees nearer the equator. In all the Natal sugar-growing areas the soils are the result of the decomposition of the underlying Ecca shales and conglomerates, with occasionally the coal-bearing sandstones (as at Tongaat) and of the basaltic rocks which intrude them so frequently. In the Umzinto district the soils are of granitic and metamorphic origin. On the Zululand littoral we have no occurrence of the latter rocks, except a small outcrop near the mouth of the Matikulu river, which is not worth taking into account. Of course we have the Engoye range, to the east of Eshowe, consisting of granitic and schistose rocks, but the elevation is against sugar growing, except perhaps in the valleys, which, however, are as a rule narrow, and contain only small patches of alluvial deposits. The Ecca series of shales, &c., as a soil-producing formation do not occur further north on the littoral than the Umlalazi river, where they begin to be overlain by the newer Cretaceous Formation, which, however, is also concealed from view by the superficial sands, &c. This is the northern coastal limit of soils produced from the rocks, which furnish in Natal the sugar-growing soils of the coast. The soils resulting from the degradation of the Ecca Series consist generally of a clayey alluvial, with locally varying quantities of sandy material. From the Umlalazi river, where the littoral is narrowest, northward into Amatongaland where it is nearly fifty miles in width, on to Delagoa Bay and into the Sofala country, the soils are of an entirely different character. Over this extensive area they are chiefly derived from the wind-blown sands of the coast, assisted in the neighbourhood of the rivers by the finer rock *débris* brought down by their waters, and to a great extent influenced by the calcareous rocks of the Cretaceous Series occurring at varying depths below these alluvial deposits, which superficially have been assisted towards the formation of a good soil, by the addition of decomposed vegetable matter from the decayed timber, scrub, &c., which have flourished from time to time over most of it. At the points where the principal rivers emerge on to the littoral from among the hills of the rising uplands, there are facilities in some cases for the permanent conservation of their waters for future distribution over large tracts of the littoral in their neighbourhood for purposes of irrigation. In many cases the fresh-water lakes and permanent pans which occur so plentifully over this flat coastal area, will also in the future be available as sources of water-supply for local irrigation purposes.

If the Government sell this country indiscriminately, reserving, as has been usual in South Africa, the best portions from an agricultural point of view for the lazy kaffir population, it will be an interesting lesson, if one were needed, of the futility of white colonisation in this part of Africa. Although the Government have not had much professional opinion on the subject, it has been quite evident to any observant outsider that the Marwarri, the moneyed Indian, and the Indian native agents who for years have flooded Natal with indigent coolies (of course under indenture), have a knowledge of the possibilities of the country, and a system of emigration, which for business principle, and I have no doubt monetary return, equals anything in European finance. This has been evidenced, as long as I have known the country, during the last five years, by the insidious coolie advance along the north coast towards the lower part of the Tugela river, where, like a flight of locusts, they have taken everything before them except a few large landowners, their ultimate object being to procure an *entrée* into Zululand.

I would impress upon the Government the fact, that, in the littoral of Zululand, which in the north is fifty miles wide, a vast area of country exists which in the future is certain to prove of great value. There is no doubt that very large areas of it will be invaluable for the production of sugar, rice, mealies, &c., and as much of it could be easily put under irrigation it would be, in my opinion, a very short-sighted policy for the Government to part with this littoral country instead of utilising it as a Government irrigation area, at least before they have had a proper professional report as to its capabilities for irrigation purposes, with reference to water-supply and conservation, and quality and distribution of its available good agricultural soils. This, of course, could not be done by a few flying trips, nor in a month or two's camping out, as it is a most difficult and tedious country to travel in. If they do not reserve the whole of it, they certainly should reserve large portions of it for this purpose, particularly where the chief rivers debouch on the littoral. As I have explained above, much of it contains ideal areas for irrigation : its physical configuration and the geological formation of its soils are admirably adapted to this purpose. If the Government retained this country for its own use it would be doing nothing out of the way as compared with other Governments. The Indian Government, for instance, holds immense areas of Government land, which is adapted for and used as agricultural country because of its facilities for irrigation. Why should the Natal Government not take the initiative and retain this land instead of letting it pass into the hands of private individuals and companies, for whose benefit in a few years they will have to institute local irrigation schemes ? In cutting up this country they will naturally part with the water-rights and river frontages necessary to the individual areas sold, and if ever, in the future, a Government scheme of irrigation is proposed, it will then be exceedingly difficult and expensive to carry it out, because it is sure to interfere in many cases with the water-supply of the landowner lower down. I would therefore suggest to the Government that before they take the final steps to allow of this area being thrown open, they should have a minute examination made of the whole littoral by a competent professional irrigation specialist, so that before they commit themselves to definite action in the matter they will have, as the basis of their action, a definite professional opinion to go upon.

On the shore, just behind the mission station, to the south of Cape Vidal, at the three-mile crossing of the southern end of St. Lucia Lake, an interesting deposit has been exposed by the denudation of the sand-dunes facing the sea. At the bottom of the sand cliff, which here is of considerable height, the lower slope is littered with enormous quantities of weather-whitened shells of various genera. The following were identified for me by Mr. Burnup: *Stenogyra* (*Obeliscus*) *lanceolatus* Pfr., *Natalina Caffra* Krs., *Cyclophorus* (*Aferulus*) *Wahlbergi*, *Pomatias insularis* Pfr., ? *Livinhacia Kraussi*. Associated with these are animal and bird bones and broken pottery. From the condition of the bones and the position of the deposit under a great thickness of sand it would appear to be of great age. No stones or pebbles of any kind were found in association with the deposit. Large numbers of sand concretions occur among the sands in which the remains are. They are mostly pipe-like, as if they had been formed around roots of plants, although some of them have taken most curious and unusual shapes with no similarity to anything in particular. They are extremely hard and the cementing material is calcareous. On many of the broken fragments of pottery there are evidences of a considerable degree of design in the ornamentation, particularly of the necks of the vessels. The greater portion of it has evidently been done with the finger-nail. Although frequently a line has been drawn completely round the vessel its accuracy is probably due to the vessel having been slowly rotated during the drawing of the line. The bones consist chiefly of the remains of the pig, together with quantities of the bones of birds of fairly large size. The deposit seems to me to be quite analogous to the kitchen middens which occur so commonly in the sand-dunes along the coast.

CRETACEOUS.

With reference to the Cretaceous area on the littoral a good deal more accurate information has been collected. There is now no doubt whatever in my mind that the entire littoral, from below Port Durnford right up beyond Delagoa Bay and westward as far as the foot-hills of the interior, consists, below the Pleistocene and Recent alluvials, chiefly of Cretaceous rocks; while in a few localities on the immediate coast, slight evidences of the presence of rocks of later age have been met with, probably Tertiaries.

The isolated positions in which the outcrops of these rocks have been visited by me would necessarily preclude the possibility of arranging them in their proper relations to each other, or giving an accurate and complete list of the whole series of beds forming the Cretaceous Formation. This will, I hope, be arrived at later on when the fossils from the various localities have been examined and named and the stratigraphy worked out. The first part of the palæontology of these rocks, consisting of the fossils of the Umkwelane Hill calcareous sandstones by Mr. R. Etheridge, is published with this report. Wherever beds of this formation are exposed they are exceedingly prolific in fossil remains, just as are the Cretaceous strata of other parts of the world. Often where there are no outward evidences of the presence of fossils apparent to the eye, the rock contains innumerable remains of minute organisms such as *Foraminifera*, *Ostracoda*, &c. These foraminiferal rocks are usually calcareous sandstones and sometimes green sandy shales. They are probably all marine or estuarine deposits, as shown by the molluscan fauna which is present, but they also often contain large quantities of fossil wood, spore cases, and other vegetable matter. On the coast at Port Durnford and at Umbonambi a thick bed occurs, which is locally composed almost entirely of stumps of trees and vegetable matter forming an impure lignite. In both localities it is associated with shales containing the remains of marine fossils, and it is just possible that it may represent the same horizon in these two places. With the exception of the calcareous sandstones and conglomerates of the Umkwelane Hill, the Umsinene river and the Manuan creek at the south end of the Lebombo range, mentioned in my last report, the Cretaceous rocks exposed in the various localities on the coast consist chiefly of shales, marls, calcareous beds and lignites, with soft sandy deposits of all colours. On most parts of the coast, however, often where there are no local outcrops of beds at all, the beach, particularly towards high-water mark, is strewn with flat boulders of all sizes with water-worn edges. These usually consist of coarse calcareous sandstones and grits, often containing fossil mollusca and foraminifera. They have probably been derived from beds which outcrop close in shore on the ocean bed, as they are not traceable to any local outcrop on land. In a few rare cases boulders of a very pure, compact limestone occur, also containing fossil mollusca, but in this case also, there was no evidence of a local outcrop of the bed, which would have been valuable for the production of lime.

Quite a number of new localities have been met with in which the Cretaceous rocks are fossiliferous. Among these may be mentioned the north-western edge of False Bay and the inner portion of St. Lucia Lake. The first-mentioned outcrop occurs on the game path on the water-level of the western side of the lake, about two miles south of the north end of False Bay. The beds are gritty, felspathic sandstones, more or less calcareous, with clays and marls. In these occur numerous fossils, chiefly *Gasteropoda* and Corals. As there was little time on the occasion of my visit to do any extensive work in the way of collecting, I had to be content with much decomposed specimens.

On the coast to the south of Cape Vidal calcareous sandstones and grits occur, lying horizontally. These are even quartzitic in places, but are usually coarse grained; while locally they are peculiarly conglomeratic. The pebbles are chiefly of quartz, often very transparent, blue slates, and other metamorphic rocks. These conglomeratic patches are peculiar and have associated with them the indistinct traces of the casts of fossils which are indeterminable because of their fragmentary condition.

Similar rocks occur on the shore at Uquobeletini Lake, some seven miles to the south of Sordwana Point.

On the coast at Port Durnford I picked up a few pebbles which seemed to me to be foraminiferal. This proved to be the case when microscopic sections of them were made. These I submitted to Mr. G. J. Hinde, of the British Museum, who kindly furnished me with the following identifications :—

"Calcareous Algæ. LITHOTHAMNION."

"Small fragments of branching forms of this genus are present" "in all the sections, and they are more abundant than any other" "organism. The cellular structure is well preserved. Rarely, an" "encrusting specimen is also met with. Probably two or three" "species are present, but with sections merely they cannot be" "definitely recognised."

"FORAMINIFERA."

"These are abundant, and their minute structure is distinctly" "shown under the microscope. The following genera are repre-" "sented, but in only one or two instances could the species be" "determined, *Biloculina*, *Miliolina*, *Spiroloculina ;* the majority of" "the forms are included in these three genera. Less numerous are" "*Textularia rugosa*, *Globigerina bulloides*, *Pulvinulina*, *Rotalia*," "and *Gypsina globulus*."

"ECHINODERMATA."

"Fragments of detached test-plates are common, and more" 'rarely, of spines."

"POLYZOA."

"Broken up fragments of several species are fairly numerous," "but from the sections alone they cannot be named."

"LAMELLIBRANCHIATA."

"A few fragmentary chips of shell. The general character of" "the organisms indicates their deposition in shallow water. I do" "not recognise any form indicating definitely the geological horizon," "but judging from the general features and the good state of preser-" "vation of the fossils, I should judge that it dates from a later" "period than the Cretaceous."

Unfortunately I was unable to locate the beds, *in situ*, from which these pebbles had been derived, but it is interesting to note that we have here evidences of the presence of rocks which may prove younger than the Cretaceous. These pebbles occurred on the coast in close proximity to the Lignite Beds which are exposed on the shore at Port Durnford from among a series of marls and sandstones.

Three years ago, specimens of a deposit which proved to contain *Diatomaceæ*, were first forwarded to me by Mr. J. Crossly, of Makowe Hills, Zululand, who owns a store some miles above the western end of Lake Sibayi. Since then I have been able to visit the locality personally.

Deposits of diatomaceous earth are not, up to the present, known to be of frequent occurrence in South Africa. Dr. Molengraaff mentioned in his report on the Vryheid District, that, with the exception of the deposits he enumerates from the Ermelo and Vryheid districts, there is only one other kieselguhr deposit known in the southern half of Africa, and that is situated near Lake Rudolf in Central Africa. The original Tripolite is derived from Tripoli, a town on the north coast of Africa, where large deposits of diatomaceous earth exist. I think, however, that it is extremely probable that in many parts of South Africa such deposits will ultimately be found to exist in considerable quantities and of good commercial value. For this reason I mention this deposit.

Because it is a non-conductor of heat, diatomaceous earth is largely used as packing for boilers, steampipes, and safes. It has also an extensive use as a polishing agent; while owing to its porous character it makes an excellent absorbent for the manufacture of dynamite from nitro-glycerine.

The deposit referred to is situated about two miles above the entrance of the creek flowing into the western end of Lake Sibayi. It outcrops in the valley, at the point where the track from Makowe to Foxon's Camp crosses the creek. It is exposed in a rude cutting on the north bank, and can be traced for a considerable distance above the crossing. Report goes that still further west, towards the watershed of the creek, large areas of a similar deposit occur. These, however, I had not an opportunity of visiting.

The country in the neighbourhood is undulating, and, as a rule, covered with dense bush. Between this and the coast, a distance of about 12 miles, it is flat and sparsely covered with bush, and in most parts it is impossible to take a waggon without having a tract cut. Over a wide area of this flat country, no rock outcrops are to be seen, but judging from the sections on the coast and in the neighbourhood of the eastern flank of the Lebombo range, it is more than probable that the strata underlying the Pleistocene and Recent superficial sands consist of Cretaceous beds. The deposit itself, though exposed for fully 20 feet in thickness, underlies the surface soils and sands, but the underlying rocks are not visible.

The exposed deposit is of a greyish-white colour. It is, as a rule, a soft unctuous substance, which when dry is very friable and will absorb a very large quantity of moisture. In different positions in the section hard white layers occur which are of a solid, stoney nature. These are frequently separated from the softer portions of the deposit by layers, of fossil fresh-water mollusca. All through the deposit, layers of minute shells, chiefly *Ostracoda* and *Foraminifera*, exist, while everywhere the casts and decomposed shells of larger mollusca are present. Among the larger shells specimens of *Planorbis Pfeifferi*, Krauss, are the most common. As a rule, however, these fossils are of such a friable nature that it is almost impossible to detach the specimens from the matrix, which is of a very calcareous character. It is even difficult to separate the larger forms from the matrix by dissolving the latter from them with dilute acid, as the shell substance is so brittle that it falls to pieces with the slightest movement. In many cases individual layers of shells consist almost entirely of specimens of the same species; particularly is this the case with the more minute forms. In no portions of the deposit is there grit or other impurities present.

The water of Lake Sibayi, unlike that of the other larger lakes of the littoral, is fresh, and there is no outlet between the lake and the sea. It is more than probable that in earlier times the superficial extent of the lake was much greater than at present. Around the western arm of the lake the undulations rise to a considerable height, and the valley of the creek which flows into it is wide and open. The deposit has no doubt been formed in this valley, either when the waters of the lake extended up as far as the road, where the valley becomes comparatively narrow, or it has been deposited in this narrow portion of the valley because of some obstruction below. As the deposit is over 20 feet in depth, its accumulation must have extended over a considerable period, and it is more likely that the former explanation is correct. The calcareous matter has been derived doubtless from the Cretaceous rocks, which underlie the Pleistocene and Recent deposits further up the creek valley.

It is probable that the deposit is of Pleistocene or late Tertiary age.

I have not come across, or heard of any other locality in Zululand where similar diatomaceous deposits exist, but as most of the northern littoral is little known it would not be at all surprising if other deposits were found of a more economically valuable character.

Through the kindness of Mr. A. W. Cooper, of Richmond, who forwarded one of my samples of the deposit to the Royal Microscopical Society, London, I am able to reproduce a short report by Mr. A. Garland on the more minute organisms present.

"The material, a grey marl, broke up readily, and the residue," "after washing on fine silk gauze of 200 meshes to the inch, was a" "light grey powder consisting of diatoms, sponge spicules, small" "sand grains, a few foraminifera, and many perfect and broken" "mollusca."

"The organisms observed were—"

"Vegetable Diatoms, a species of *Campylodiscus*, is abundant," "and is shown on the enclosed rough spread mount of the finer" "residue."

"A few vegetable fragments, especially the objects marked with" "an X on the enclosed card mount. I think these are fruits of" "Chara or some allied form. I have met with similar objects in" "many British shore gatherings and in some tropical shallow-water" "gatherings."

"Animal *Foraminifera*, a weak variety of *Rotalia beccarii*, is "fairly abundant; the specimens are thin-walled and starved, and "quite devoid of characteristic features. They might with almost "equal safety be assigned to the genus *Discorbina*."

"Besides this form, I have seen a few specimens of *Nonionina depressula*, W. & J., and a single specimen of *Miliolina fusca*, Brady."

"*Sponges*.—Many spicules of monactinellid sponges."

"*Ostracoda*.—Many specimens of several varieties."

Mollusca.—Numerous specimens."

"There is nothing in the Foraminifera which entitles me to "speak with authority on this matter, but, speaking generally, I "should say that it is certainly not older than Pliocene, more pro- "bably a raised coast deposit of sub-recent age, and that it was "originally laid down in a shallow and brackish estuary, or perhaps "a lagoon such as are nowadays found on the East African coast."

Two analyses of the deposit were made at the Government Analyst's Department, Durban, which are given below:—

	Lake Sibayi. (1)	Lake Sibayi. (2)		Mauritius.		Germany.
Silica	16·19	29·60	...	92·20	...	82·97
Ferric oxide	1·12	0·96	...	2·5	...	6·82
Alumina	1·91	2·84	...	2·5	...	7·13
Lime	40·64	37·15	...	—	...	—
Magnesia	0·85	0·97	...	—	...	—
Moisture	1·50	2·55	...	21·0	...	8·45
Loss by ignition	2·92	2·92	...	—	...	—

It will be seen from a comparison between these analyses that this Zululand deposit is very poor in silica, as compared with the two typical examples of good commercial Tripolite from Mauritius and Germany given above, and on this outcrop is of no commercial value. The high percentage of lime is certainly to be accounted for by the presence of such large quantities of fossil land shells and *Ostracoda* in the deposit. Here, however, the exposure is of no great extent, but it is possible that in the neighbourhood the deposit may be more extensively developed, while its composition may be more like the normal and commercially valuable Tripolite. In any case such a calcareous deposit as this will always be valuable for agricultural purposes.

ECCA SERIES.

With regard to the occurrence of the Ecca Series in Zululand, I have been enabled to define locally many of its limits. In much of the country examined containing this formation it has been possible to define the areas of Lower Ecca Shales and thereby limit in these districts the possible presence of coal in the coal-bearing Upper Ecca Sandstone Series. So far as my examination of this series has gone, the lower shales, overlying the glacial conglomerate, show no evidences of the presence of coal, and I think it may be now taken for granted that wherever these lower shales outcrop the prospects of payable coal are of the most meagre kind. Even among the Upper Ecca Sandstone Series, in which geological position all our coals east of the base of the Drakensberg occur, the presence of payable coal is most uncertain, because of the irregularity of the deposition of these beds.

In the early days, as shown by the quotation given below, the idea among geologists was that all the coal-bearing strata in South Africa belonged to the same period.

"It is, however, not improbable that as the great outcrops of"
"coal in this portion of South Africa show themselves along the"
"Vaal Valley, and also in the Transvaal, *west of the* Drakensberg,"
"associated with rocks possessing an easterly dip, and that they"
"appear again in the Utrecht Division of the same Province, as"
"well as at Biggarsberg (Newcastle) in Natal, *to the eastward* of the"
"same range, *that these are all outcrops of the same coalfield* of which"
"the present Drakensberg mountains occupy the synclinal trough."
"If such should, after proper investigation, prove to be the case,"
"*the supply of South African coal* will prove to be enormous, and"
"casting the figures quoted—vast as they may appear—completely"
"in the shade."[*]

Since the above paragraph was written in 1878 by that able geologist, Mr. G. W. Stow, who did so much for the advancement of our knowledge of South African geology with little recognition or recompense to himself, much information has been obtained by his geological successors with regard to the coal-fields of South Africa. It will be seen from the above paragraph that Mr. Stow puts forward the suggestion that in all the localities where coal was then known to occur, in the Stormberg district of Cape Colony, in the Orange River Colony, in the Biggarsberg and Utrecht districts of Natal, he identified the various coal-bearing strata, occurring in these different localities, as belonging to the same geological horizon. This, however, has hardly been borne out by subsequent investigations, the palæontological evidence of which has shown that there are two series of coal-bearing strata in South Africa, separated from each other by a considerable thickness of beds, chiefly shales, which form what is recognised as the Beaufort Series of the Karoo Formation. Mr. E. J. Dunn years ago pointed out this fact, and likened the Karoo coal-bearing series to that of New South Wales, Australia, where there are two horizons on which payable coal occurs, the lower of which is at no great distance above the Permo-Carboniferous glacial deposits. The Beaufort Series is largely developed over a considerable area in Cape Colony, its outcrop flanking both sides of the Stormberg range, and passing westward forms the watershed between the coastal rivers and the tributaries of the Orange river as far as the Great Riet river. In Natal it is quite recognisable outcropping from beneath the Upper Karoo Beds on the lower slopes of the Drakensberg, and extending a considerable way to the eastward. Over the coastal districts of Natal and Zululand we find nothing higher geologically than the Upper Ecca coal-bearing

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[*] Stow, G. W., "Report of the Geological Survey of the Orange Free State from the 18th April to the 18th December, 1878." Bloemfontein, 1879.

Series. We have examples, however, to the north of Pietermaritzburg of the occurrence, in shales of Beaufort age of the remains of typical fossil *Dicnynodonts*.

The Stormberg Series above, the Beaufort Beds, and the Ecca Series below, both furnish large quantities of fossil plant remains. These occur in both cases among the shaley layers associated with the coal-bearing portion of the series. Isolated plant remains also occur among the sandstones. In the Ecca Series of Natal and Zululand the plant and coal-bearing beds occur in the upper portion of the series, at a considerable distance above the Ecca (Dwyka) Conglomerate. These remains are characterised by the enormous quantities of specimens of *Glossopteris* of various species, which are the most common of all the plant remains. The Stormberg Series, which outcrops on the lower slopes of the Drakensberg range, are, on the other hand, characterised by the presence of a totally different flora, the principal genera being *Thinnfeldia* and *Tœniopteris*.

I had an opportunity towards the end of 1902 of working out the geological relations between the coal-bearing series of Zululand and that of the Vryheid District as described by Dr. Molengraaff, the Geologist to the Transvaal Government in 1898. In the basin of the Black Umfolosi, in the district to the north of and between the Mahlabatini and Nongoma Magistracies, the Ecca Series, from the glacial conglomerate upwards, is well developed. In the valley of the Begamuse creek the glacial Ecca Conglomerate outcrops, and here we have the base of the series. To the west, towards Keza Mountain extensive outcrops of this same formation occur ; while on the range on which the Nongoma Magistracy is situated, the horizon of the Ecca coals is present. That there is no doubt about this correlation is shown by the presence, both in the shales at the court-house and at the coal-outcrops some miles south of the Magistracy, of plant remains, consisting chiefly of specimens of *Glossopteris* and *Phyllotheca*. In all the intervening beds down to the glacial conglomerate no fossil remains have yet been discovered. In this district the succession is practically the same as that described in my first report, in the Eccas of the Natal coast and the other Zululand coal-bearing Eccas. The whole series is certainly not so thick here as it is elsewhere; but the black shales overlying the glacial conglomerate are well marked, succeeded by lighter coloured sandy shales and sandstones, among which the coal seams occur. All these portions of the series can be traced right up to the border of the Vryheid District. From the other side Dr. Molengraaff has mapped (see his map[*]) the whole Ecca Series up to the same boundary. As regards the Ecca (Dwyka) Conglomerate there is no room for doubt. The overlying black shales, which he recognises as Ecca, are also undoubted. The higher beds, which occur usually in the upper portions of the flat-topped isolated hills all over the district, and consist of sandstones, shales, and coals, he has grouped as representing the Beaufort and

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[*] Molengraaff. Annual Report of the Geological Survey of the South African Republic for 1898. Pretoria, 1901.

Stormberg Series. With this identification I cannot agree. He even admits that wherever fossils were obtained they invariably consisted of a *Glossopteris* flora which is totally distinct from the *Thinnfeldia* and *Tœniopteris* flora of the Stormberg Series in Cape Colony, and is typical of the Ecca Series immediately above the glacial conglomerate. Particularly in the district around Nongoma these Upper Ecca coal-bearing beds can be distinctly traced into the Vryheid District as the representatives of these so-called Stormberg Sandstones of Dr. Molengraaff. Not only is the palæontological evidence strong in favour of all this series being one and the same (Ecca), but the stratigraphical evidence is absolutely convincing.

The relation of these Vryheid Beds to the Newcastle and Dundee Series of Natal is also equally simple. The palæontological evidence shows the same state of matters, a *Glossopteris* flora in both cases, while the stratigraphy shows that they are one and the same series. In fact, it may be simply stated that, so far as we know, with the exception of the coal-bearing series at the base of the Drakensberg—which is undoubtedly of Stormberg age (containing *Thinnfeldia*, &c.)—all the coal-bearing rocks of Natal and Zululand are unquestionably much older, contain a *Glossopteris* flora, and are of Ecca or Permo-Carboniferous age.

see H + C
for picture.

Years ago, Mr. E. J. Dunn recognised the fact that in Cape Colony coal-bearing rocks occurred on two distinct horizons—one in the Stormberg Series, and the other in the Ecca or Kimberley Shales. This inference was drawn rather from the analogy which the South African Karoo formations bore to the Lower Mesozoic rocks of Australia, than to actual local geological proofs. On this hypothesis he advocated the testing, by boring, of those large areas, under which the Ecca Series was known to occur. His contention has since been borne out; first, by the discovery of workable coal in the Ecca Series at Vereenigin, and now by the fact that all our coals east of the Drakensberg in Natal, Zululand, and the Vryheid District, belong to the Upper Ecca periods. From what we know of the occurrence of coal in these various coal-fields, the evidence goes to show that it has been anything but uniform, and the presence of payable coal is of quite a local character, and therefore boring for coal over the large tract of country in the northern part of Cape Colony would be an exceedingly uncertain operation, although there is little doubt in my mind that coal will be found to be present among the Ecca Series in some portions of this large area. There is nothing on the surface to show where such localities occur. In Natal and Zululand no such difficulty exists, because the Ecca Series has been exposed and cut through by surface denudation, thereby laying open the whole series of strata among which the coal occurs, and affording every opportunity to the prospector, of investigating the coal-bearing capacity of these rocks in any district in which they are present.

A further examination of the Ecca Series in the low country to the south-east of Eshowe, in the Umlalaas District has revealed the fact that in the basin of the Matikulu river the series is of no great thickness. On the northern side of the lagoon at the mouth of that river a small outcrop of granite occurs ; while on the shore, a little to the south, at the mouth of the Inyoni river, large deposits of black sand are present. The latter could only have been derived from rocks much older than the Eccas, so that probably at this part of the coast there is a considerable development of metamorphic rocks, which, however, are mostly covered with the Pleistocene and Recent sands, and very likely form a portion of the sea-bottom in the neighbourhood of the river mouth. Beacon Hill, some miles up the river, consisting of sandstones with thin shales, may either be an outlier of Table Mountain Sandstones, or sandstones associated with the Ecca Conglomerate, such as occur to the south of Hlabisa, but I think it is more likely to be the former. In either case its geological position is much below the coal-bearing Eccas. To the south-west on the watershed, and in the valleys of the southern tributaries of the Matikulu river, as far west as the Umsindusi river, there is a large development of glacial conglomerate. Some miles further to the north-west the Table Mountain Sandstones appear on the main Eshowe coach road. In the extensive bend of the Inyezane river (a northern tributary of the Matikulu) a large portion of the Ihlobenganga Hill consists of glacial Ecca Conglomerate, which can be seen at the bottom of the hill, on the east, to overlie a coarse sandstone.

In the Inyezane creek, however, a short distance to the east of the hill, carbonaceous shales, with abundant fossil-plant remains, undoubtedly of Ecca age, occur. Reports of coal outcrops from this neighbourhood have frequently been made, but no seams of a payable nature have yet been opened up. From here, north-eastward to the mouth of the Umlalaas river, the Ecca Coal Series is present. A good deal of prospecting and boring has been done, resulting in the discovery of coal seams of much too anthracitic a character for ordinary uses.

In the area of the basin of the Matikulu river (leaving out that of the Inyezane) the coal-bearing series of the Eccas is not present, owing to the denudation having gone so far as to expose the metamorphic rocks near the coast, and inland the glacial Ecca Conglomerate of the Ecca Series, and the Table Mountain Sandstones. This area therefore circumscribes the Umlalaas coal-field on the south. Still further to the south, on the north of the Tugela river, at its mouth, an outlier of carbonaceous Ecca Shales exists, among which there are slight traces of poor coal, but I should think that here, over this small area, surrounded by outcrops of Ecca Conglomerate, the shales would be portions of the lower Ecca Series, and therefore, notwithstanding the reported occurrence of supposed coaly layers among them, that it is very unlikely that there is any chance of their being coal-producing. The Umlalaas Coal-field is, therefore, cut off to the south along the Matikulu river-valley by the presence, at the surface, of these metamorphic rocks, and further inland, by the lower portion of the Ecca Series. The productive coal-bearing area in this coal-field is undoubtedly to the north, near the Umlalaas river, where we have the deepest portion of the

Ecca Series. To the north of the Umlalaas river this coal-bearing series is overlain by the Cretaceous calcareous sandstones, &c., and the Pleistocene and Recent sands, which attain a considerable thickness to the north, and would make it practically impossible to even prospect these coal-measures, at least for a long time to come. In this area, a little south of the Umlalaas river, coal-seams of workable thickness have recently been struck in a Government bore, but are generally of a semi-anthracitic character.

In passing through the St. Lucia coal-field, I took the opportunity of seeing a little more of the palæontology of these coal-measures. The collections made are now being examined and described. This coal-bearing series is undoubtedly of Ecca age, as shown by the various beds of shale containing a *Glossopteris* flora. One of these fossiliferous shales, exposed in the creek-bed, on the northern boundary of Mr. Reynolds' coal-mining lease, contains enormous quantities of a very large form of *Glossopteris*, some of the individual leaf impressions, in their perfect state, being more than 8 inches in length.

Associated with this *Glossopteris* bearing shale-bed is an outcrop of limestone, which rock is of very rare occurrence among the beds of this formation. So far as I saw there do not appear to be any fossil remains of any size in this rock, which seems to be of some thickness, and is quite likely to be of some economic value. Mr. J. J. Garrard has shown me specimens of an impure limestone, whose outcrop he discovered among the shales to the south, between the coal-fields railway station and the Umfolosi river. This, however, is probably a different bed to that mentioned above, but may possibly represent the calcareous bed which outcrops, with a slightly east-of-north strike a couple of miles to the west of the old Magistracy, which used to be situated close to the northern road, to the south of the Umfolosi river.

Considerable activity has lately taken place on this coal-field, which is now the terminus of the Zululand railway. Boring operations have been carried out on an extensive scale, and shafts and cuttings have been made for prospecting and working purposes on Mr. Reynolds' lease. In one of the bores the coal-bearing portion of the shales was struck on the dip at about 265 ft. From this point down to 310 ft. coal and shale alternate, as follows : Coal 10 ft., shale 5 ft. 11 in., coal 1 ft. 4 in., shale 1 ft. 4 in., coal 4 ft., shale 8 in., coal 1 ft. 9 in., shale 1 ft. 7 in., coal 1 ft. 10 in., shale 2 ft., coal 2 ft. 10 in., shale 1 ft. 3 in., coal 9 in., shale 9 in., coal 2 ft. 10 in., shale 1 ft., coal 3 ft. 3 in., shale 1 in., coal 2 ft. 1 in. In the same bore at 480 ft. in depth, 5 ft. of coal was struck, and at 488 ft. another seam of 4 ft. The quality of the coal is not stated.

GLACIAL ECCA CONGLOMERATE.

The Ecca (Dwyka) Conglomerate has a much wider distribution than would at first appear from a preliminary geological traverse of Zululand. The most frequent occurrences of its outcrops are as outliers, which have been left by superficial denudation on the higher ridges and mountains. In these positions it occupies considerable areas to the north and north-west of Eshowe, and in the neighbourhood of Melmoth and Ulundi; while to the north of Mahlabatini, towards the Vryheid and Swazieland borders, and in the southern coal-field of the Umlalaas, it outcrops from under the denuded portions of the Ecca Shales. It will be seen from the position of the localities mentioned above, that, as in the coastal districts of Natal up to the 3,000 feet plateau, the glacial Ecca Conglomerate occurs in Zululand at all heights from sea-level up to the highest portions of the plateau, at the western border of the province. In all the cases that I have seen, this difference of level has not been caused by subsequent faulting. On higher outcrops the Ecca Shales are rarely or never developed in association with the glacial conglomerate, and I think that the reason for this is, that, probably after the retreat of the ice the higher portions of the country, with their covering of terrestrial glacial detritus, were never again submerged. Such an area is occupied by the high granitic and metamorphic country, forming the Engoye Mountains and the districts lying to the west of Melmoth and Eshowe, towards Nkandhla. To the north of this area, in central Zululand, to the north-west in the Vryheid District, and to the south-eastward in the Umlalaas coal-field on the littoral, we have large areas which have been submerged—in evidence of which we have the presence of the Ecca Series overlying the glacial conglomerate.

In some cases the configuration of the old Permo-Carboniferous land surface can still be identified, as exposed by denudation. For example, the valley of the Umhlatuzi river, from the upper Eshowe and Melmoth road crossing, presents the following features. Both sides of the valley for a considerable distance are formed of Palæozoic and Granitic rocks, the south side consisting of Table Mountain Sandstones and the north of granites, &c., locally capped by Table Mountain Sandstones. These rise to about 2,000 feet above the bed of the valley. A section of the south side of this valley is shown in Fig. 2, on Pl. VI. In the bed of the valley resting unconformably on the Table Mountain Sandstones are the glacial Ecca Conglomerates, while these are overlain by some thickness of Ecca Shales. About 1,000 feet up on the south side, near Lowe's Store, there is a development of shales which are much higher in the Ecca Series than those in the bed of the valley, and among which an inferior coal-seam has been known for some time. It would look extremely probable that the present-day Umhlatuzi river has been denuding these Ecca Shales and the glacial conglomerate below, out of an old Permo-Carboniferous valley which extended westward into the granitic and metamorphic area towards Nkandhla, and eastward towards the northern end of the Engoye Mountains.

There is now no doubt whatever in my mind that the glacial Ecca Conglomerate of the east coast, as far as I have had an opportunity of examining it from St. John's river to the north-western parts of Zululand, and over the Vryheid and Utrecht Districts, is of terrestrial origin and is an ancient till or boulder clay, as the late Dr. Sutherland years ago recognised it to be in Natal. It is, in fact, analogous in this respect to the northern outcrop of the glacial conglomerate of Cape Colony, which has been shown by Dr. Corstorphine to be a terrestrial deposit. Unfortunately over this large area on the east coast there are few localities where it exists in its original thickness, because wherever it is at present exposed it has undergone a very large amount of denudation. There are a few localities, however, where the thickness is very considerable, as in the valley of the Umkomaas river to the west of Richmond where the Umquambane river enters the Umkomaas. The differences of level, from the higher to the lower points of occurrence do not, however, here, as almost everywhere else, represent the actual thickness of the deposit, which has probably been laid down on a sloping and irregular surface. This is a typical deposit of glacial conglomerate, consisting of an argillaceous base, uniformly sprinkled with pebbles and boulders of all sizes. So far as I have seen, it contains no sandy deposits.

In a few localities in Zululand I have come across sandy beds particularly free from pebbles and boulders, intercalated among the typical pebbly glacial conglomerate.

In two localities this is particularly well seen. One of these is in the neighbourhood of Ulundi, and the other is about five miles to the south of Hlabisa Magistracy, towards the lower part of the Umfolosi game reserve. In both localities the sections are exceedingly good, and the evidence is very clear, of the existence of the sandy beds among the glacial conglomerate, although in the neighbourhood of the latter localities there is a certain amount of complication in the relations of the glacial conglomerate to the sandstones associated with them. This, however, is not the case in the actual sections referred to above.

Notwithstanding the large area, both in Natal and Zululand, over which this formation is exposed, the presence of intercalated sandy deposits is not at all of common occurrence. At none of the exposures that I visited do they show distinct lamination. The sand grains are usually coarse, but they do not constitute the entire bed as isolated pebbles occur, often striated; while occasionally, distinct horizontal layers of coarser grit and pebbles are present, which are practically the only evidences of stratification that occur. In the glacial Ecca Conglomerate itself irregular layers of coarser material are not uncommon, arranged in a more or less horizontal manner. An example of this occurs in the face of the Umgeni quarry, near Durban, on the north side of the river. Although generally coarse, the sand grains are of all textures, and patches of very fine-grained material are common. The majority of the pebbles are never much rounded, but usually more or less angular and subangular, and are frequently scratched, smoothed, and faceted. As a rule they are of small size, and never attain the dimensions of boulders. These sandy deposits among the glacial Ecca Conglomerate seem to be of a purely local character, In the neighbourhood of Ulundi there are at least two well-marked sandy deposits among the glacial conglomerate, outliers of which cap the Table Mountain Sandstones of the Uvula range to the south-east, is exposed over the whole of Ulundi plains and forms the hill, to the north-west, behind the Ulundi store on which the Nkonjeni and Intendega trig. beacons are situated. To the east, south, and west of Ulundi there is no development of the Ecca Shales, but on the western point of this range, to the west of the Nkonjeni trig. beacon, overlooking the Umfolosi river valley, the Ecca Shales outcrop, overlying the glacial conglomerate which is exposed at the base of the range, in close proximity to the finest specimen of a glaciated pavement that I have yet seen. It is formed of quartzite in the bed of the Umfolosi river, and is beautifully striated, and the glacial conglomerate can be seen still resting on the surface of the quartzite, where the river has not yet denuded it away. This pavement occurs at the north-east end of a sharp bend of the Umfolosi river near which there is the ruins of a store, to the north-west of Mabehlane Hill. These quartzites are associated with the Hospital Hill Series, which are largely developed to the westward in the neighbourhood of the Denny Dalton Mine.

The lower of the two sandy beds, outcrops in the creek which drains the Ulundi plain, where its exposure is not of any great extent. As it is below the general level of the plain which consists entirely of glacial conglomerate, an idea of its lateral extent is not obtainable. In composition it is a coarse-grained grit with isolated pebbles, of small size, and collections of pebbles usually arranged in more or less horizontal layers. The transition between it and the glacial conglomerate below and above is gradual, although the probability is that at the upper edge there is a slight unconformity. In all its characters it is distinctly different from the ordinary glacial conglomerate. This is so marked that its outcrop immediately attracts attention.

The upper sandy deposit outcrops on the southern face of the hill behind the Ulundi store. The plateau-like top of this ridge consists of a basaltic sill, immediately underneath which the glacial Ecca Conglomerate outcrops. Below this, in the cliff, the upper sandy deposit occurs, resting again on glacial conglomerate, which merges at the base of the hill into that of the plain. This sandy bed is of considerable thickness, and is quite a distinctive feature in the cliff when viewed from a distance. It is lighter in colour than the glacial conglomerate, and gives the hill, with its capping of basalt, the appearance of being composed of sedimentary strata. Its outcrop is, however, nearly vertical, and it is practically impossible to show it on the map. The actual thickness of the glacial Ecca deposits, here, from below the lowest outcrops on the Ulundi plain to the top of the outcrop on the hill behind Ulundi store must be very considerable. In almost all the areas in Zululand where this formation is present a similar condition occurs, the glacial deposits are of greater thickness at the lower levels. To a large extent this may be due to the effects of subsequent denudation, which has had more effect upon the deposits outlying on the present ridges and hills than on those exposed in our present valleys. At the same time, as I have previously stated, it is, I think, exceedingly probable that in many cases our present rivers are now denuding the terrestrial glacial deposits left in the valleys and depressions of the old Permo-Carboniferous land surface, and that wherever we get great thicknesses of glacial conglomerate they represent the land surface depressions of Permo-Carboniferous times, in which, naturally, the thickest deposits of glacial *débris* would be accumulated.

The upper deposit is much more uniformly sandy than the lower on Ulundi plain. There is no evidence of the presence of the former to the south-east of the plain, although outliers of the glacial conglomerate occur on the top of the Uvula range, which forms the other side of the valley. It is probable, I think, that it never extended so far as to cover the area now known as Ulundi plain, but was merely local in its occurrence (Pl. VI., Fig. 1). In lateral extent its outcrop extends from below the Mahlabatini Magistracy along the southern face of the ridge to the Umfolosi river, in an east and west direction.

The other locality in which a sandy deposit occurs among the glacial Ecca Conglomerate is about five miles to the south of the Hlabisa Magistracy. The sections are exposed in the valleys of the creeks, which are the lower eastern tributaries of the Mona river, near where it joins the Black Umfolosi river. It is of considerable thickness, but its lateral extent is not traceable for any distance. It possesses much the same characters as the sandy deposits at Ulundi.

Molengraaff mentions in the Vryheid District both stratified and non-stratified beds in the conglomerate. The former are argillaceous, and cannot be distinguished from the Ecca Shales which are of the same composition as the gangue of the glacial conglomerate.

Intercalated beds of grit are mentioned by Professor David in the Australian glacial deposits, in which fossils, chiefly *Gangamopteris*, have been found. So far as I have observed, fossils do not occur in immediate association with our glacial deposits; but plant-bearing beds are present among the upper Ecca Shales which are separated from the glacial conglomerates by a series of fine shales, having all the characters of the matrix of the glacial conglomerate and being quite unfossiliferous. The presence of these, overlying the conglomerate, would point to the fact of a gradual but permanent diminution in the glacial conditions of climate, and I do not think that these sandy beds intercalated among the glacial conglomerate represent or are analogous to the interglacial sands and deposits which occur among the Pleistocene glacial deposits of the northern hemisphere. The explanation given by Dubois,* where he says, "Ce sont toutes des" "formations glaciaires, la partie stratifiée et pauvre en blocs ayant" "été formée vers les bords du domaine des glaces, les conches" "d'Ecca étant du limon, déposé durant le recul et la fonte de la" "masse glaciaire," is not applicable in the case of these Zululand sandy deposits. That deposits with such an origin will be found to exist somewhere close to what was the limit between the terrestrial boulder clay and the glacial sedimentary deposits which were formed off the land, like those forming the Ecca glacial beds in Southern Cape Colony, is extremely likely. But the sandy deposits of which I speak occur in the middle of the terrestrial boulder clay, and cannot possibly represent the former edge of the ice-sheet or glacier. In the South African area there exist, in the south of Cape Colony, sedimentary glacial deposits, which are undoubtedly contemporaneous with our terrestrial glacial Ecca Conglomerate, and therefore there must be a line between the terrestrial and sedimentary glacial deposits which would represent approximately the old Permo-Carboniferous coast line from which the icebergs were calved, whose melting set free the material from which the sedimentary glacial deposits were formed. The deposits in the neighbourhood of this line would necessarily consist of the finer *débris* which was washed from the edge of the ice-sheet, while most of the heavier material was carried further off and deposited as sedimentary strata. No reasonable explanation of the presence of these sandy beds among the conglomerate presents itself, and more investigations must be carried on in reference to these and other similar deposits before a satisfactory explanation of their origin is obtainable.

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* Les causes Probables du Phénomène Paléoglaciaire Permo-Carboniférien dans les Basses Latitudes. Archives Teyler, Ser. 2, Tome viii., Quatrième partie.

TABLE MOUNTAIN SANDSTONES.

A better understanding has now been obtained of the distribution and economic value of the Table Mountain Sandstones. In almost every district in which this formation is to be met with, the portions remaining, consist of the basement beds with a varying number of the lower beds overlying them. The thickness of the formation exposed therefore differs very widely in the outcrops in different localities. To the east of Melmoth there is a thickness of over a thousand feet of sandstones, while at Ungangatu Hill, a few miles to the north of Hlabisa, the thickness of this formation exposed between the Metamorphic Series and the Ecca Conglomerate is not more than a few feet. This consists of a basement conglomerate formed of beautifully rounded and smoothed pebbles and boulders, cemented together by a silicious matrix.

Similar sections to this one are of frequent occurrence in many districts of the province, particularly in the country to the south-west of Eshowe. These sections always exhibit an unconformity between the Metamorphic Series and the rounded pebble conglomerate, and the same is the case between the latter and the glacial Ecca Conglomerate, although the unconformity is not so easily noticed in this case. I have not seen any glaciated pavements on this thin bed of conglomerate below the Eccas. The reason why this peculiar basement conglomerate of the Table Mountain Sandstones is still present so thin in these localities, is that the unconformity between the Table Mountain Sandstones and the Ecca Conglomerate shows much more denudation of the Table Mountain Sandstone in these localities than is usual elsewhere, resulting in the whole series having been denuded away, with the exception of a very small thickness of the basal conglomerate. This is not usually easy of recognition unless the exposed section is a good one, but when once recognised similar occurrences can readily be identified, even if the exposed section does not show the upper unconformity.

About two miles up the Umhlatuzi river, above the crossing of the Melmoth and Nkandhla road, a remarkable development of these pebbly basement beds of the Table Mountain Sandstones occurs. The lowest bed is exposed in the Umhlatuzi river itself, and consists almost entirely of well-rounded pebbles, generally about the size of a hen's egg, although larger and smaller pebbles are also present. They chiefly consist of quartz, quartzite, and jasperoid rocks, and their rounded and water-worn aspect is quite typical of the same basement conglomerates wherever I have seen them. Although the rock is exceedingly hard and difficult to break, the matrix, which is silicious, is infinitesimal in amount. This enormous preponderance of the pebbles and boulders over the matrix is a remarkable feature in this rock. The overlying beds differ somewhat from the bed just described in that the pebbles and boulders gradually become a less prominent feature in the rock until we pass by gradations to the sandstones with occasional isolated pebbles or local collections of them. These beds bear a strong resemblance, on a casual view, to the more pebbly portions of the glacial Ecca Conglomerate. In some cases large boulders occur among the otherwise pebbly and small-stoned conglomerates. In no case, however, did I notice that the pebbles or boulders were scratched, but the non-existence of striæ on the pebbles and boulders in the glacial Ecca Conglomerate is quite a common feature of that deposit. The whole character of these beds would almost give one the impression that they had been formed, not as an ordinary sedimentary deposit, but through the agency of floating ice. Undoubted evidence has lately been furnished by Mr. Rogers, of the Geological Survey of Cape Colony, of the presence of ice-scratched pebbles in certain beds of the Table Mountain Sandstone Series of that Colony. So far as we know this formation on the east coast there is as yet no positive evidence of the glacial origin of any portion of it, but the subject is worthy of further investigation.

In my first Report, at page 91, I stated that, because of the want of fossil evidence, it was then impossible to correlate the Palæozoic Sandstones with either the Table Mountain Sandstones or the Witteberg Series of Cape Colony. Since then I have had opportunities of seeing various outcrops of both series during two official visits to Cape Colony. Petrologically our east coast Palæozoic Sandstones differ from both the Cape formations referred to, as they chiefly consist of variously coloured sandstones with few shales among them. They are never, except owing to local intrusions, quartzitic—a character which is typical of both the Cape formations. Stratigraphically there is, at least in the south, no continuity of outcrop between these various formations. The southern exposure of our Palæozoic Sandstones in Natal disappears into the Indian Ocean in the neighbourhood of St. John's river mouth, and the first outcrop of the Cape Palæozoic Formations is in the district of Port Alfred to the west of East London. In neither of the formations have any fossil remains of any palæontological value been met with. The east coast Palæozoic Sandstones, so far as my knowledge of Natal and Zululand goes, are the only representatives of the Palæozoic Formations of Cape Colony. No trace has yet been discovered of the Bokkeveld Beds, and it is even doubtful if our Metamorphic Series represents any portion of the Malmesbury Beds. We have, however, on the Umfolosi river, at the western boundary of Zululand, a small development of the Hospital Hill Series of Johannesburg.

Of the two formations, the Table Mountain Sandstones and the Witteberg Quartzites, the east coast Palæozoic Sandstones seem to me to more closely resemble the former. There are certain points of resemblance between the two. There is the common absence of interbedded shales, the frequent occurrence among the series of coarse conglomerates containing well-rounded and water-worn pebbles, often with patches and pebbles of clay of various colours. The general character of these conglomerates is peculiar, so far as I have seen to these two formations. I think, on the whole, that the Palæozoic Sandstones of the east coast will prove to be the equivalent of the Table Mountain Sandstones of Cape Colony ; and I have now no hesitation in adopting Sutherland's correlation, and therefore in future will use the name Table Mountain Sandstones instead of Palæozoic Sandstones.

The omission of the two other Palæozoic formations, the Witteberg and the Bokkeveld Beds, is represented by the unconformity between the glacial Ecca Conglomerate and the Table Mountain Sandstones ; while the unconformity between the Table Mountain Sandstones and the Metamorphic Series represents a number of Palæozoic Formations which are present in the Transvaal. Both unconformities represent a very lengthened period of time.

The absence of any relics of the Witteberg Quartzites or the Bokkeveld Beds may be due to either of two causes, that they had never been deposited over the eastern area or that they had been completely denuded away before the accumulation of the Ecca Conglomerate. That large quantities of quartzitic rocks existed somewhere in the eastern area seems to be beyond dispute, because of the enormous numbers of pebbles and boulders of quartzites entirely unlike any of the rocks occurring locally, which are present in the glacial Ecca Conglomerate. It may be said that these were probably transported from a distance, but if it is true, as is likely, that our eastern glacial Ecca Conglomerate is of terrestrial origin, the moraines of our local ice-sheet, then the boulders, &c., must have had a more or less local origin. In fact, in many localities in Natal this is borne out by the occurrence in the glacial conglomerate of fragments of local rocks, easily identified as such. I think it is more than likely in this case that during later Palæozoic times, what now represents our east coast area was then on the eastern edge of the area of deposition, with the result that in none of the formations was the deposition of any great thickness over this area, while its central portion, where the greatest deposition took place, was to the west, in the central part of South Africa. A similar set of conditions must have persisted through earlier Mesozoic times, for we find the respective thicknesses of the components of the Karoo Formation very different. In the central part of South Africa these various divisions of the Karoo Formation, the Eccas, &c., are of enormous thickness as compared with the same series of beds on our eastern coast.

This formation is much more developed in the south-western portion of the Province than is the case in the eastern half. The south-western end of the metamorphic area of the Engoye range is flanked by the eastern edge of the Table Mountain Sandstone Formation, which is largely developed to the west and south. The town of Eshowe is built upon it, and it is owing to this fact that in the neighbourhood of the town, springs of excellent water exist at the head of every gully; in fact, up to the present time these springs have furnished the entire water-supply of the town. Lately a well was sunk at the new gaol, but after going 80 feet it was abandoned as no water was obtained. The fallacy of this is apparent when one notes that the gaol is situated on the top of a ridge, from both sides of which the water in the sandstones is naturally drained into the valley below, by the springs. It seems evident that to sink for water on the top of the ridge, one would naturally conclude that to obtain water at all it would be necessary to sink at least to near the level of the springs which are the natural outlets of the water. It is exceedingly probable that if this were done a good supply of water would be obtained, the depth in this case being of no great account, owing to the amount of convict labour at hand.

It caps the hills southwards to the Tugela river, and is continuous across that river with the Table Mountain Sandstones of Victoria County, shown on my map (First Report, Pl. XIX.). Its eastern limit on the river occurs a few miles above the railway bridge near Lower Tugela (Bond's Drift), and its outliers are present far into the Nkandhla District to the west. North from the river, its limit is the range to the west of the Eshowe road, which it crosses a few miles north of the Matikulu river drift, where the road begins to rise the foothills, to get on to the range of metamorphic rocks above. The foothills here consist of Table Mountain Sandstones, and a narrow outcrop of them flanks the Engoye Mountains for some distance to the north-east, intervening between them and the coal-bearing Ecca Series of the Umlalaas flats. On the northern side of the Engoye Mountains a similar occurrence takes place. An outcrop of Table Mountain Sandstones flanks the range along the road from Eshowe to Lower Umfolosi, where it is present between the Ecca Series of the Umhlatuzi river valley and the Metamorphic Series of the Engoye range. They persist past the south side of Magwagazi Hill and occupy the Umhlatuzana river valley as far as the Umhlatuzi river at Hlabane

Hill. To the north they are largely developed in the Melmoth District as far as the Black Umfolosi river, where they attain a considerable thickness. To the east of Melmoth there is a great thickness of them where they disappear towards the Ntambanana coal-field, below the coal-bearing Ecca Series. In the northern part of the province the only position in which they are present is to the north of Hlabisa, where there is a small patch which can with certainty be referred to the Table Mountain Sandstones, but this district will have to be more minutely examined before the exact area occupied by this formation can be accurately defined. Near Hlabisa; in the neighbourhood of Melmoth; to the north-west and west of Eshowe and to the south of Lowe's Store; they are capped by outliers of glacial Ecca Conglomerate.

In some districts in Zululand there is great difficulty in distinguishing these sandstones from the sandstones of the coal-bearing Ecca Series, while in the south-western part of the Umlalaas coal-field, for instance, it is hardly possible without a minute survey. Another area is that in the neighbourhood of the Hlabisa Magistracy. Before the accurate geology of this area is known, a much more detailed survey than I have yet been able to make will be required. To the south of the Magistracy the glacial Ecca Conglomerate exists in more than one bed, being interstratified with sandstones which present a remarkable likeness in general petrological characters to those of the Table Mountain Sandstones; while the sandstones of the Upper Ecca Shales, which also occur in the neighbourhood, produce another factor in detracting from the accuracy of result from a rapid survey. In the sketch-map of Zululand (Pl. XX.) accompanying my First Report, an area is coloured Palæozoic Sandstones in the neighbourhood of Hlabisa. This will, however, I find, on further field-work, have to be much restricted, chiefly to a small area in the neighbourhood of Ungangatu and Ingogong Hills to the north of the Magistracy, where it is exposed between outliers of glacial Ecca Conglomerate and two small exposures of granite and metamorphic rocks. To the north and west the country consists of the Ecca Shales with numerous intrusions of basalt. About a couple of miles to the west of Ungangatu Hill I came across some indistinct impressions of plants in the shale, which could be identified as *Glossopteris*.

IGNEOUS ROCKS

Between the Hlabisa and Lebombo Magistracies, to the north of the Nongoma and Makowe road, the Umsundusi river, a tributary of the Mkuzi, drains a large area of mountainous country called the Umgweme ranges. When the river leaves the ranges it crosses the flat country forming the Makowe game reserve, and then has cut its way, by a precipitous gorge, through the Rhyolites of the Lebombo range, and flows into the Mkuzi river on the eastern side of the Lebombo. The rocks forming the Umgweme Mountains are of a most interesting description. They are of a distinctly granitic type, and probably originated as intrusive rocks among a series of sedimentary rocks of much greater age than the Ecca Series, which now surrounds the present outcrop. In the valley of the Umsunduzi river, a couple of miles to the north of Dingatuli Hill, they are overlain unconformably by the Ecca Shales. Unfortunately this is the only portion of the boundary of their outcrop that I have yet had a chance of visiting, but here there is no doubt about the unconformity, although no glacial Ecca Conglomerate appears. On the south side of Dingatuli Hill outcrops of the black shales which immediately overlie the glacial conglomerate occur. A short distance higher up the river thin-bedded sandstones are present, but the relations they bear to the Ecca Series was not satisfactorily made out. They are certainly much older than the Ecca Series, and are probably of Palæozoic age, if not older. Additional support is given to this idea from the fact that some miles to the south, near the Hlabisa Magistracy, outcrops of granites and metamorphic rocks occur associated with the basement beds of the Table Mountain Sandstones and glacial Ecca Conglomerates. In fact, the geological evidence points to the conclusion that we have an area certainly of no great width, but stretching from about ten miles south of Hlapisa Magistracy north, to the Umgweme range, consisting at no great depth from the surface, of Palæozoic and other more ancient rocks. On the track, some ten miles to the west of the Lebombo Magistracy, outcrops of similar rocks of limited extent occasionally occur; and probably, further north to the west of the Lebombo range in Swazieland, they are present in association with the granitic and metamorphic rocks of that country. In the accompanying map I have not separated these rocks from the basalts of Makowe Hills because my knowledge of them is as yet limited, but there is no doubt that in the future they will have to be depicted by a special geological colour.

CRETACEOUS FOSSILS OF NATAL.

PART I.—THE UMKWELANE HILL DEPOSIT, ZULULAND.

By R. ETHERIDGE, ESQ.,
Curator of the Australian Museum, Sydney, N.S.W., Australia.

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CRETACEOUS FOSSILS OF NATAL,

COLLECTED BY

MR. WILLIAM ANDERSON, Government Geologist.

PART I.—THE UMKWELANE HILL DEPOSIT,

BY

R. ETHERIDGE, ESQ.,

Curator of the Australian Museum, Sydney, N.S.W., Australia.

I.—INTRODUCTION.

The fossils described in subsequent pages were forwarded to me by Mr. William Anderson, Government Geologist of Natal, for determination and description. They were collected at Umkwelane Hill, about twenty miles above the mouth of the Umfolosi river, which flows into Saint Lucia Bay, on the Zululand coast.

The deposit may be described in general terms as a shelly limestone, the matrix a calcareo-arenaceous rock of a grey-brown colour. It is so crammed with fossils as to become a shell-agglomerate, the matrix harder than the fossils. The result is that in attempting to disengage the latter the shells invariably break up. This has rendered extraction for descriptive purposes almost an impossibility, and I have in consequence had to depend on portions. Fortunately, however, some of the more important species are so plentiful that the general characters of each can be more or less constructed.

This fossiliferous deposit was evidently known to Mr. C. L. Griesbach. In his most instructive paper "On the Geology of Natal" "in South Africa,"* he speaks of the "Cretaceous Rocks of South" "Africa," and says, "Between the rivers Umtamfuna † and Umzam-" "bani, about five miles from the southern boundary line of Natal, on the" "south-eastern coast of Africa, some deposits are found which at first" "sight seem to be of the same material. They consist of sandy marls" "and hard sandstones of a greyish-brown colour, with a few calcareous" "concretions. . . . These rocks only extend for a short distance, and" "only form isolated cliffs. They are found, too, at the Impengati river," "and at some of the more southern rivulets which run into the sea" "between the boundary of Natal and the St. John's river (Umzim-"

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* Quart. Journ. Geol. Soc., 1871, xxvii., p. 53.

† Griesbach spells this locality Umt*am*funa, but Mr. Hellier Baily writes it Umt*a*funa (Quart. Journ. Geol. Soc., 1855, xi., p. 453).

" vooboo). The same are also recognised in the bed of a small stream " "running into the St. Lucia Bay in the Zulu country. The strata " " forming these deposits are perfectly horizontal, and they rest upon a " " sandstone of much older age, which belongs to the very interesting " " series of the Karoo formation." [*] The latter portion of the quotation is the only reference I am acquainted with directly bearing, possibly, on the spot from which Mr. Anderson's fossils were collected.

The Umtafuna Beds were, previous to the appearance of Mr. Griesbach's paper, referred to by Capt. R. J. Garden,[†] and the fossils collected by him described by Mr. W. H. Baily,[‡] who considered the collection to represent a series " probably palæontologically equivalent " "to the Upper Greensand of this country [England] and *Craie Chloritée* " "of France." [§] Subsequently Prof. R. Tate, when dealing with the fossils of the Uitenhage formation, referred to this deposit and its contents in a table of the South African Secondary Beds as " Cretaceous." [||]

II.—DESCRIPTION OF THE SPECIES.

1. PELECYPODA.

GENUS OSTREA, *Linnæus*, 1758.

(Systema Nat., Ed. X., 1758, p. 696.)
(Pl. II., Figs. 1 and 2.)

Obs.—The existence of Oysters in the Umkwelane Beds is shown by a few small specimens in a poor state of preservation. One is the interior of a valve and its relief, having a diameter of one and a quarter inches. It is almost circular, and exhibits traces of a crenulated margin. The adductor impression is subantral.

Another specimen consists of a small, thin, flat valve, with a longitudinal diameter of eight millimetres and a transverse diameter of six millimetres. There is an obscure umbo and a few concentric laminæ.

GENUS EXOGYRA, *Say*, 1819.

(American Journ. Sci., 1819, i., p. 381, ii., p. 43.)
(Pl. II., Figs. 3-6.)

Obs.—Indefinite examples of a small *Exogyra*-like bivalve, but the material is much too limited to permit of satisfactory determination. The flat valve very much resembles Tate's *Placunopsis imbricata*,[¶] and the convex valve his *Ostrea* (*Exogyra*) *jonesiana*.[**] In both instances, Tate's and mine, the two are probably the upper and lower valves of one form.

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[*] Quart. Journ. Geol. Soc., 1871, xxvii., pp. 60–61.

[†] *Ibid.*, 1855, xi., p. 453.

[‡] *Ibid.*, p. 454.

[§] *Ibid.*, p. 464.

[||] *Ibid.*, 1867, xxiii., p. 167.

[¶] Quart. Journ. Geol. Soc., 1867, xxiii., p. 154, t. 8, f. 7.

[**] *Ibid.*, p. 154, t. 8, f. 3*a–c*

GENUS NEITHEA, *Drouet*, 1824.

(Ann. Soc. Linn. Par., 1824, iii., p. 183.[*])
(Pl. II., Fig. 13.)

Obs.—A cast of a portion of the lower or convex valve, with what appears to be a part of one auricle, may be referred here. There are portions of five primary costæ remaining, prominent and rounded, the intercostal spaces faintly concave or flattened, and without traces of secondary costæ on the body of the shell, but on the lateral slope there are traces of these crenulating the margin. The umbo is imperfect, but enough remains to show that it was high and much over-curved. The remaining auricle is small and triangular, and if this feature were omitted the specimen might pass for a portion of a valve of *Cucullæa Kraussi*, Tate,[†] but on the whole I give the preference to *Neithea*. Baily quotes *Pecten quinquecostatus* from the Umtafuna and Umzambani deposit,[‡] and so does Griesbach.[§]

GENUS MELINA, *Retzius*, 1788.

(Dissert. Hist. Nat., 1788, p. 22.)

MELINA ANDERSONI, *sp. nov.*

(Pl. II., Figs. 7–10.)

Sp. Char.—Shell subquadrate, equivalve, tumid, strongly biconvex, alate posteriorly; cardinal margins long and straight, thickened and flattened with oval resilifers extending for rather less than half their length; ventral margins rounded. Anterior ends very small, formed only by the steep anterior slopes which are hollowed immediately below the umbones, and then swell out below; no auricles. Posterior ends composed of almost four-fifths of the valves, very tumid and convex from the umbos downwards, rapidly falling away still further posteriorly to more or less flattened alations; posterior slopes ill defined, rounded; posterior cardinal angles obtusely rounded. Umbos quite anterior, incurved. Adductor impressions invisible. Sculpture of regular, concentric, somewhat gradate laminæ, with finer intermediate lines, the former becoming flatter and less marked on the posterior wings. Test laminar, thin.

Obs.—An exceedingly tumid and convex form, with a thin test, laminar in structure, and externally resembling some forms of equivalve *Inoceramus*. There do not appear to be any anterior auricles, but the ends are steep and under the umbone excavate, simulating the so-called "circumscribed lunule" of *Anopæa*, Eichwald.[**] The resilifers are also similar to those of that genus, but whether or no our shell possessed the "rib-like tooth in the left valve below the beak" I am unable to say, nor have I seen any definite trace of a byssal sinus. As in many other shells with a thin test, there is no trace on the internal cast of the adductor scars.

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[*] *Teste* Herrmannsen, Indicis Gen. Mal., ii., p. 110.

[†] See Holub and Neumayr, Denk. K. Akad. Wissenschaft., Wien, 1882, xliv., p. 275, t. 2, f. 2*a*–*c*.

[‡] Quart. Journ. Geol. Soc., 1855, xi., p. 462.

[§] *Ibid.*, 1871, xxvii., p. 66.

[**] Lethæa Rossica, 1865–68, ii., p. 479.

Melina Andersoni bears no relation to *M. Atherstoni*, Sharpe, sp.,* of the Zwartkop Group, and is named in honour of Mr. William Anderson, Government Geologist of Natal.

GENUS GERVILLIA, *Defrance*, 1820.

(Dict. Sci. Nat., 1820, xviii., p. 502.)
(Pl. II., Figs. 11 and 12.)

Obs.—Two small forms of this genus are present in the collection, both single valves.

One (Pl. II., Fig. 11), is longitudinally ovate, without any apparent anterior alation, but possessing a strong diagonal ridge proceeding from a finely pointed umbo, and an alate posterior end, which is, unfortunately, broken off short. The sculpture consisted of very delicate concentric lines. Although so small it may possibly be of the type of *G. linguloides*, Forbes, of the Atherfield Clay of the south of England.

The second specimen (Pl. II., Fig. 12), unlike the preceding one, exhibits an anterior alation, and a small posterior wing, and in consequence a proportionately longer cardinal margin. The surface bore fine latilaminæ and intermediate delicate striæ. It is of the type of *G. alæformis*, D'Orb., a Neocomian species.

Every probability exists that both these little shells are species of *Gervillia*.

GENUS PINNA, *Linnæus*, 1758.

(Systema Nat., Ed. x., 1758, p. 707.)

Obs.—A single specimen in the form of the median portion of an exfoliated left valve, one and three quarter inches long, by one and a half inches wide. Beyond the fact that it represents the genus little more can be said of it, other than that it seems to represent a more elongated species than *P. Atherstoni*, Sharpe,† of the Uitenhage Group.

GENUS MYTILUS (*Linnæus*), *Lamarck*, 1799.

(Mém. Soc. Hist. Nat. Paris, 1799, p. 88.)
(Pl. I., Fig 7.)

Obs.—A portion of a valve apparently of a Mytiloid shell, possessing characters of its own sufficient for future recognition, and is therefore figured. The surface is covered with rough latilaminæ reminding one of those of *Inoceramus*, but the structure of the test does not accord with that of the latter.

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* Trans. Geol. Soc., 1856, vii. (2), Pt. 4, p. 193, t. 22, f. 4, 4*a*–*b*.

† *Ibid.*, 1856, vii. (2), Pt. 4, p. 193, t. 22, f. 1.

GENUS TRIGONIA, *Bruguiere*, 1789.

(Encycl. Méthod., 1789, t. xiv.)

TRIGONIA UMKWELANENSIS, *sp. nov.*

(Pl. I., Figs. 14–19.)

Sp. Char.—Shell ovately sub-trigonal, very inequilateral, and very moderately tumid. Cardinal margins arched anteriorly and centrally, but almost straight posteriorly; anterior and ventral margins regularly rounded. Anterior ends small and compressed; posterior ends long, the valves very gradually losing their convexity towards the produced rostrations, the margins of which are obliquely rounded. Umbones sub-anterior, but little elevated; diagonal ridges very faintly marked, curved; posterior slopes elongately triangular, flattened, and traversed by one longitudinal median groove. Cardinal teeth unknown. Anterior adductor scars faintly marked; posterior adductor scars triangular, excavate on their anterior sides; pallial line distinct; intermarginal areas very wide, particularly posteriorly; siphonal ridges strongly impressed in casts. Sculpture consisting of plain strong costæ, about twelve in number, sub-concentric on the umbonal regions, becoming gradually less and less curved, until on the posterior ends they become vertical (longitudinal); on the posterior slopes are sub-crescentic rugæ, one corresponding to each costa; neither tubercles nor granules at any stage of growth.

Obs.—I have given this shell a distinctive name in relation to the locality yielding it. I believe it to be a member of the group of *T. scabra*, Lamk., as defined by Stoliczka, and *T. elegans*, Baily,* but not having seen the cardinal teeth I cannot speak with certainty. It is, however, distinguished from both the foregoing by an entire absence of tubercles and granules in the sculpture, and from the latter alone by possessing a less number of costæ. There are a large number of specimens in all stages of growth from four mm. in longest diameter to thirty mm., representing the adult condition; none, unfortunately, are perfect, but the condition of the portions is such that the characters of the species can readily be arrived at.

The outline to a great extent resembles *Trigonia Shepstonei*, Griesbach,† as well as that of *T. elegans*, Baily,‡ but the sculpture is wholly different from that of the former, and the posterior cardinal margin straighter. The costæ very closely resemble those of *T.*

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* Quart. Journ. Geol. Soc., 1855, xi., t. 13, f. 3*a* and *b*.
† *Ibid.*, 1871, xxvi., p. 66, t. 3, f. 11.
‡ *Ibid.* 1855, xi., p. 461, t. 13, f. 3.

ventricosa, Krauss, * from the Uitenhage Formation, but the umbonal region of the latter is far too elevated for our shell. This feature is particularly well shown in the recent figures of *T. ventricosa* given by Müller †

It is interesting to note that in *T. umkwelanensis*, we have a *Trigonia*, more or less resembling one from the *Umtafuna* horizon in Natal, or as Griesbach terms it the Izinhluzabalungu deposits.

GENUS TRIGONARCA, *Conrad*, 1862.

(Proc. Acad. Nat. Sci. Philadel., 1862, xiv., p. 289.)

TRIGONARCA UMZAMBANIENSIS, *Baily*, sp.

(Pl. I., Figs. 1-5.)

Arca umzambaniensis, Baily, Quart. Journ. Geol. Soc., 1855, xi. p. 460, t. 13, f. 1.

Obs.—The specimens before me are all imperfect, as it was found impossible to extract other than imperfect ones from the agglomerate. Such as they are, however, they indicate a tumid, obliquely triangular, carinate and abruptly truncate shell. The cardinal margins are moderately long, and slightly curved, the ventral margins obliquely curved anteriorly, nearly straight centrally, and rounded posteriorly, with the faintest indications of cinctures; the posterior margins are obliquely and sharply truncate. From the not very prominent umbos very elevated keel-like diagonal ridges pass, forming the highest portions of the valves, with the posterior slopes almost at right-angles to them, whilst the remainder of the surfaces are flattened and gradually slope away to the anterior margins. The cardinal areas are moderately wide, triangular, arched on each side of the umbones, and bear about five strong arched ligamental grooves, with indications of vertical teeth in the centre of the articulus. The intermarginal areas within the valves were deeply excavate, the margins of the latter denticulate, and the test solid and thick.

The sculpture is both concentric and radiate, the concentric lines fine, with at irregular distances more deeply impressed latilaminæ, crossed by fine and very numerous costæ, producing by their intersection a fine cancellation.

I believe this to be Baily's species, although the position in which his figure represents the shell renders identification rather difficult. His expression, "the keel is elevated, and is the highest part of the shell," however, completely describes the present fossil. On the other hand the valves of *Arca capensis*, Griesbach, ‡ are uniformly rounded, and the diagonal ridges do not constitute the highest portions of the valves. As Griesbach expresses it, " Mr. Baily's figure represents a much flatter specimen than mine."

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* Nova Acta Acad. Cæs. Leopol.—Carol. Nat. Gur., 1850, xxii., p. 456, t. 49, f. 2.

† Bornhardt's Deutsch-Ost-Afrika, 1900, vii., t. 19, f. 4 and 5.

‡ Quart. Journ. Geol. Soc., 1871, xxvii., p. 66, t. 3, f. 10, 10*a* and *b*,

The articulus is imperfect in all the specimens I have examined, but the external appearance of the valves is so unmistakably that of the genus *Trigonarca*, Conrad, particularly those forms figured by Stoliczka from the Indian Cretaceous beds, that I do not hesitate to refer Mr. Anderson's fossils to it. Amongst the Indian species may be mentioned *T. abrupta*, Forbes,* of the Trichinopoly Group, even more than to *T. trichinopolitensis*, Forbes, with which Mr. Baily compared his species.

GENUS LATIARCA, *Conrad*, 1862.

(Proc. Acad. Nat. Sci. Philadel., 1862, xiv.)

LATIARCA (?) NATALENSIS, *Baily*, *sp.*

(Pl. I., Figs. 10–12*a*.)

Arca natalensis, Baily, Quart. Journ. Geol. Soc., 1855, xi., p. 461, t. 13, f. 2*a* and *b*.

Obs.—Numerous fragmentary examples of an Arca, presenting all the external features of Baily's species. They represent a transverse obliquely-ovate shell, produced ventro-posteriorly, inflated, but with the general surfaces gently rounded between the anterior margins and the diagonal ridges, the highest point of each valve being in a line with its umbo. The cardinal margins are very little arched, and the ventral margins rounded, passing obliquely into the anterior margins; the posterior edges are obliquely truncate. The posterior diagonal ridges are obtusely rounded, the posterior slopes flat, and almost at right angles to the remainder of the valve surfaces. The sculpture is both concentric and radiate, with very numerous costæ covering the whole of the valves, sharp at the extremities, somewhat flattened centrally. There are the usual latilaminæ at irregular distances apart, with intermediate fine lines, which in passing over the costæ decussate them and produce a succession of remarkably fine frills. Two of the costæ on the posterior slopes are often more prominent than the others, with the surface between the cardinal margins and the first costa, between the latter and the second, and between this and the posterior diagonal ridges slightly concave, the last concavity exhibiting a central groove. These can even be faintly distinguished in Baily's figure.

It may be added from Baily's description and figure that the cardinal area is large with four divaricating ligamentary grooves. The central cardinal teeth are slightly oblique, the laterals declining outwards, and bent down at their inner ends. The adductor impressions do not appear to be strong, but the intermarginal area is wide, and the margins interlocking.

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* Stoliczka, Cret. Fauna S. India (Pal. Ind.), 1871, iii., Pts. 5–8, p. 352, t. 19, f. 4, 5, and 5*a*.

It appears to me, on the whole, that this shell should be referred to *Latiarca*, Conrad, although it is impossible to say, from Baily's figure, whether or no both the central and lateral teeth were striated, or only the latter, as in *Idonearca*, Conrad.

Baily suggested a resemblance between his specimens and *Arca japetica*, Forbes (*Macrodon* vel *Grammatodon*, Stoliczka),* but this form appears to me to be too much inflated.

GENUS CARDIUM, *Linnæus*, 1758.

(Systema Nat., Ed. x., 1758, p. 678.)

CARDIUM BULLEN-NEWTONI, *sp. nov.*

(Pl. II., Figs. 14–16.)

Sp. Char.—Shell ovately subquadrangular, subinequilateral, inflated, especially in the umbonal region; edges internally denticulated; test thick. Cardinal margins short, rather less than the actual width of the valves. Anterior and ventral margins rounded; anterior slopes not truncate, but obliquely declinate. Posterior margins slightly rounded, forming by their junctions with the cardinal margins slight alations; posterior diagonal ridges sharply defined, but not carinate; posterior slopes truncated. Umbonal regions inflated, and the umbones high. Adductor scars faint, but placed high up on the anterior and posterior slopes. Sculpture consisting of numerous (more than twenty) projecting rounded costæ, separated by flat valleys of greater width than themselves, crossed at intervals by fine concentric frills, which echinate the costæ.

Obs.—This is a common and characteristic shell at Umkwelane Hill, but the specimens are always fragmentary. To a slight extent it resembles *Cardium denticulatum*, Baily,† but is much more tumid in the umbonal regions, with the result that the anterior and posterior slopes are more pronounced. The free extension of the costæ on the posterior margins represented in Baily's figure of *C. denticulatum* is not an uncommon feature in species of this genus, and in itself hardly a specific character, although I have seen no definite trace of it in the present shell. The latter is more nearly allied to *C.* (*Acanthocardium*) *pullatum*, Stol.,‡ of the Indian Trichinopoly Group, but seems to be rather more longitudinally elongated, and also to differ in the same points as it does from *C. denticulatum*, but in a less degree. The outline generally is that of *C.* (*Trachycardium*) *productum*, Sby., as figured by Zittel from the Gosau deposits, even to the slight posterior alation in each valve. This species, referred by Stoliczka to *Trachycardium*, Morch, is placed by Gabb § in a special genus—*Granocardium*. The information I possess regarding the articulus of *C. Bullen-Newtoni* is very meagre. There seems to be a long and stout projecting cardinal tooth in the right valve. There is no suggestion of the sculpture of *C. productum* and its allies.

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* Cret. Fauna S. India (Pal. Ind.), 1871, iii., Pts. 5–8, p. 350, t. 18, f. 6–11.

† Quart. Journ. Geol. Soc., 1855, xi., t. 13, f. 4*a* and *b*.

‡ Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1–4, p. 218, t. 11, f. 8–10.

§ Pal. California, 1869, ii., Sect. 3, p. 266.

GENUS PROTOCARDIUM, *Beyrich*, 1845.

(Zeit. Malakol., 1845, p. 17.)

PROTOCARDIUM HILLANUM, *J. Sby.*, *sp.*, *var.* umkwelanensis, *var. nov.*

(Pl. I., Fig. 6.)

Obs.—A thick rotund subequilateral right valve, with the surface regularly and evenly convex, the posterior slope forming a continuity of the general convexity, and not a truncate surface. The anterior and ventral margins are regularly rounded, and the posterior margins obliquely truncate. The posterior slope occupies slightly less than one-third the width of the valve, and is not separated from the body of the latter by a diagonal ridge, the surface being flush. It is decorated certainly by twelve, and perhaps fourteen, radiating costæ, crossed by wavy concentric laminæ, the remainder of the valve by flattened rugæ, fine on the umbonal region and gradually increasing in strength towards the front.

Griesbach, in his list of Izinhluzabalungu fossils, records *Cardium hillanum*,* to which the present fossil bears a strong resemblance, although it seems to be more produced posteriorly and more truncate. Allowing, however, for the wide variation of form in the Indian shells figured by Stoliczka,† it will be difficult to exclude the present valve from the above species. With the view of distinguishing its occurrence in the Umkwelane beds the above varietal name is used.

GENUS ERIPHYLA, *Gabb*, 1864.

(Pal. California, 1864, i., Sect. 4, p. 180.)

ERIPHYLA LENTICULARIS, *Goldfuss*.

(Pl. I., Figs. 20-21.)

Eriphyla lenticularis (Goldf.), Stoliczka, Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1-4, p. 181, t. 6, f. 7-13.

Sp. Char.—Shell roundly-discoidal, compressed, but thickest in the middle, gradually sloping away on all sides. Cardinal margins slightly arched; anterior, posterior, and ventral margins rounded and insensibly graduating into one another. Umbones small, pointed, touching; lunule lenticular, moderately deep and long. Sculpture consisting of broad latilaminæ, bearing close regular, fine, concentric lines, becoming more marked towards the front or ventral margin; no radii.

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* Quart. Journ. Geol. Soc., 1870, xxvii., p. 62.

† Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1-4, p. 219, t. 12, f. 8-10; t. 13, f. 1-3.

Obs.—I have not succeeded in isolating the articulus of this fossil, but it is so like the above species of the Upper Cretaceous of Europe, and the Indian Trichinopoly Group, that I do not hesitate to regard the shells collected by Mr. Anderson as a small variety of it. There is also a marked resemblance to Tate's *Astarte pinchiniana*,[*] from the Uitenhage Formation.

ERIPHYLA (?) RUPERT-JONESI, *sp. nov.*

(Pl. I., Fig. 8.)

Sp. Char.—Shell ovate-subtrigonal, inequilateral, rather compressed. Cardinal margins long; ventral margins rounded. Anterior ends somewhat narrowed, the margins rounded, and the surface gently convex; no pronounced anterior or posterior slopes. Lunule long, elongately heart-shaped, well divided off from the anterior ends. Escutcheon long and deep. Anterior adductor impressions rather excavate; posterior adductor impressions flush with the inner surface of the valves, sub-pyriform in outline, concentrically lined. Pallial lines well within the margins, leaving wide intermarginal areas; sinuses wide and moderately deep; tongues short and wide. Sculpture consisting of very regular concentric rugæ.

Obs.—In common with most of the shells in this deposit, the remains of the present one are too fragmentary to permit of the preparation of a more detailed description. The principal characters are the very oblique anterior outline, a well-marked elongated lunule, and a similar escutcheon.

E. Rupert-Jonesi closely resembles those forms referred to *Eriphyla* by Müller, from Eastern Africa, such as *E. Stuhlmanni*, Müller.[†] *Venus arcotensis*, Forbes, recorded by Griesbach [‡] from the Izinhluzabulungu Beds, may be distinguished by the characters indicated above, and so may both *Astarte longlandsiana*, Tate,[§] and *A. pinchiniana*, Tate, [||] both occurring in the Uitenhage Formation, as well as *A Hertzogii*, Haurm,[¶] of the same beds. The last named species is also a much more inflated one, a feature well shown in Goldfuss' figure.[**]

The rapidly inclined anterior outline and elongated escutcheon are very like the similar characters of *Astarte* (?) *Barroni*, Newton,[††] from the Jurassic beds of Madagascar, but the correspondence stops here. Another species, figured by Müller [‡‡] from the Kimmeridgian of German East Africa—*Astarte, sp.* is by no means unlike.

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[*] Quart. Journ. Geol. Soc., 1867, xxiii., t. 9, f. 7*a* and *b*.

[†] Bornhart's Deutsch-Ost-Afrika, 1900, vii., t. 21, f. 3.

[‡] Quart. Journ. Geol. Soc., 1871, xxvii., p. 62.

[§] *Ibid.*, 1867, xxiii., p. 158, t. 8. f. 5*a* and *b*.

[||] *Ibid.*, p. 157, t. 9, f. 7*a* and *b*.

[¶] Nova Acta for 1847 (1850), p. 447, t. 47, f. 2*a* to *e*.

[**] Petrefacta Germaniæ, t. 149, f. 10*b*.

[††] Quart. Journ. Geol. Soc., 1889, xlv., t. 14, f. 9.

[‡‡] Bornhart's Deutsch-Ost-Afrika, 1900, vii., t. 17, f. 7.

GENUS CYTHEREA, *Lamarck*, 1806.

(Ann. Mus., Paris, 1806, vii., p. 132.)

CYTHEREA (?) KAFFRARIA, *sp. nov.*

(Pl. ii., Figs. 20–22.)

Sp. Char.—Shell of medium size, oblong, gently convex, inequilateral, moderately produced posteriorly. Cardinal margin arched, with a marked degree of obliquity on the posterior end; ventral margins rounded; anterior margins fully rounded; posterior margins obtusely rounded. Umbones small, acute, rather projecting, and very prosogyrate; anterior and posterior slopes ill-defined, no diagonal ridges; lunule inconspicuous, hardly defined from the anterior ends. Sculpture of very sharp and regular concentric rugæ.

Obs.—This is a common shell in the deposit. In the absence of details of the articulus, it is devoid of definite characters, other than the sharp and very prosogyrate umbones, oblique posterior cardinal margin, and very regular concentric rugæ. It possesses a general resemblance to *Cytherea sculpturata*, Stol.,[*] of the Cretaceous (Arrialoor Group) of Southern India, except that the anterior ends are less produced, the posterior cardinal margin more obliquely inclined, and the lunule is undefined.

GENUS CICATREA, *Stoliczka*, 1870.

(Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1–4, p. 192.)

CICATREA, *sp. ind.*

(Pl. I., Fig. 13.)

Obs.—An interesting fragment is represented in the above figure that from its very sharp and slightly sigmoidal diagonal keel or ridge and obliquely truncated posterior end suggests a reference to either *Cicatrea*, Stoliczka,[†] or *Pseudo-trapezium*, Fischer.[‡] It is an internal cast with indications of a thick test, and so far as the outline can be conjectured with a strong resemblance to *Cypricardia bathonica*, D'Orb,[§] the type of *Pseudo-trapezium*, or to *P. rostratum*, M. and L. sp.[||] The fragmentary state of the specimen renders it impossible to refer it with any certainty to either of the foregoing genera, and more particularly to *Cicatrea*, with its peculiar articulus and bifurcated ligament groove. Again, a comparison may with advantage be made with a shell termed by Stoliczka *Cyprina Forbesiana*, in which there is also a very strong diagonal ridge. Amongst already described South African fossils *Corbula* (?) *rockiana*, Tate,[¶] from the Uitenhage formation, presents a faint resemblance, but this form is a much less oblique shell.

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[*] Cretaceous Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1–4, p. 173, t. 7, f. 7–9.

[†] Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1–4, p. 192.

[‡] Man. Conchyl. et Pal. Conchyl., 1887, fas. 11, p. 1075.

[§] Morris and Lycett, Mon. Gt. Oolite Mollusca, 1853, Pt. 2, p. 75, t. 7, f. 8.

[||] *Ibid.*, *loc. cit.* f. 9.

[¶] Quart. Journ. Geol. Soc., 1867, xxiii., p. 159, t. 8, f. 8.

GENUS TAPES, *Mühlfeldt*, 1811.

(Ges. Nat. Freunde Mag. Berlin, 1811, v., p. 51.)

Obs.—A single and very imperfect specimen (Pl. I., Fig 9) may be referable to this genus.

GENUS DONAX, *Linnæus*, 1758.

(Systema Nat., Ed. x., 1758, p. 682.)

DONAX ANDERSONI, *sp. nov.*

(Pl. II., Figs. 23–25.)

Sp. Char.—Shell small, ovately trigonal, moderately convex. Cardinal margins abruptly arched beneath the umbones, the anterior portions slightly convex, and the posterior rapidly bent down, almost forming right angles; ventral margins rounded dentate.[*] Anterior ends long, produced, and obtusely pointed; posterior ends short, truncated above, slightly oblique and rounded below. Umbones small, apparently turned to the posterior. Articulus unknown, except that there seems to be a long lateral in the right valve; escutcheon long, occupying the whole of the cardinal margins on the posterior ends. Sculpture of numerous, close, and very fine radiating costæ.

Obs.—When first dealing with this little shell I took it to be a radiate *Nucula*, but the absence of taxodont teeth and a nacreous interior dispelled this idea. By combining the outline and sculpture *Donax* seems to assert the strongest claim, although it is most unfortunate that I have not been able to distinguish the pallial line impressions.

Donax is by no means a common genus in rocks of Cretaceous age. ***D. latus***, Gabb,[†] from beds of this period in California is very like it, possessing a similarly truncated posterior end, and radiate sculpture, but our form does not exhibit the high umbonal region of Gabb's species. ***D. Andersoni*** is distinguished from *D. Fordii*, Conrad;[‡] met with in the Raritan Clays of New Jersey, by possessing a much more truncate posterior end. Stoliczka[§] has described an unnamed ***Donax*** from the Trichinopoly Group of India.

GENUS MACTRA, *Linnæus*, 1767.

(Systema Nat., Ed. xii., Pt. 2, p. 1125.)

MACTRA (?) ZULU, *sp. nov.*

(Pl. II., Figs. 17–19.)

Sp. Char.—Shell small, thin, sub-ovate, almost equilateral, tumid, particularly in the umbonal region. Cardinal margins arched; ventral margins rounded. Anterior ends almost equal to the posterior, their margins, although rounded, inclined to become subangular; anterior diagonal ridges rounded and inconspicuous; anterior slopes rounded. Posterior ends slightly produced, obliquely sub-truncate, the margins oblique above; diagonal ridges sharp and keel-like; posterior slopes flattened. Umbonal region prominent, elevated; umbones apparently rather obtuse. Sculpture of regular concentric latilaminæ, bearing fine coincident lines, but assuming a roughened appearance when worn.

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[*] Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1–4, p. 173, t. 7, f. 7–9.

[†] Pal. California, 1869, ii., Sect. 2, Pt. 1, p. 183, t. 30, f. 75.

[‡] Whitfield, Mon. U.S. Geol. Survey (Powell's), 1885, ix., p. 171, t. 23, f. 1.

[§] Cret. Fauna S. India (Pal. Ind.), 1870, iii., Pts. 1–4, p. 136, t. 5, f. 4.

Obs.—This is a small and common little shell, with the outward appearance of a *Mactra;* the internal features are unknown. There is a general resemblance to *M. gracilis*, M. and H.[*] of the Fort Pierre Group, North American Cretaceous, and to *M. nitidula*, M. and H.[†] of the Fox Hills Group, of the same formation. Müller also figures a small Mollusc from the Neocomian beds of East Africa not unlike it, except that in the latter the shell is proportionately rather too long for its breadth.

GENUS CORBULA, *Bruguière*, 1792.

(Encyclop. Méthod., 1792, t. 230.)

CORBULA, *sp. ind.*

(Pl. II., Figs. 26 and 27.)

Obs.—No true *Corbula* has, so far, I believe, been described from the Upper Mesozoic beds of South Africa. The small shell now under consideration is again an example of the disadvantage arising from dealing with fragmentary material, particularly in the absence of dental characters. I can merely suggest that it may be a *Corbula*, on the grounds of its tumid umbonal region, apparent inclination to the posterior, sub-truncate posterior end, and regular, delicate, concentric rugæ. There also appear to be very delicate, almost microscopic, longitudinal decussating lines.

2. GASTEROPODA.

GENUS ALARIA, *Morris and Lycett*, 1850.

(Mon. Moll. Gt. Oolite, 1850, Pt. 1, p. 15.)

ALARIA (?) BAILYI, *sp. nov.*

(Pl. III., Figs. 4–8*a*.)

Sp. Char.—Shell fusiform; spire elevated, of numerous whorls (eight or nine); apex obtuse, pupa-like. Whorls moderately convex;

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[*] Report U. S. Geol. Survey Territories (Hayden's), 1876, ix., p. 209, t. 17, f. 18 *a* and *b*.

[†] *Ibid.*, p. 211, t. 30, f. 6, 6 *a* and *b*,

body-whorl elongately fusiform, expanding into a broad flattened wing, with a rounded and entire margin, the posterior angle obtusely pointed, and no carinæ; sutures shallow. Inner lips slightly reflected; anterior canal moderately long, straight; posterior canal none. Sculpture consisting of very delicate and regular thread-like lines extending over the surface of all the whorls, but more conspicuous on the posterior portions of the anterior whorls contiguous to the sutures; the four or five posterior whorls bear no costæ, but the remainder (anterior) carry regular, equidistant slightly curved ribs, which on the body whorl degenerate into obtuse, elongated tubercles; the intercostal spaces carry fine lines of growth, interrupting the spiral threads on the wing, the spiral threads have an uneven or fluctuating appearance.

Obs.—Portions of this shell are common throughout the deposit, although no absolutely perfect example is present. The wing is without digitations, but terminates at its upper or posterior angle in an obtuse or somewhat thickened point. The margin of the wing is rounded and entire, and there is no carina on the body-whorl. Some forms of *Alaria* possess costæ on the body-whorl—*e.g.* *A. rostrata*, Gabb, [*] apparently without carinæ leading to alar digitations. Although perhaps not a typical *Alaria*, the present species appears to coincide with the characters of that genus better than with those of any other. Had it not been for the presence of the long anterior canal, I would have felt disposed to refer this shell to *Arrhoges*, Gabb, from the presence of the obtuse posterior termination of the wing, and the all but entire absence in *Arrhoges* of a posterior canal.

In the structure of its posterior whorls *A.* (?) *Bailyi* exhibits a strong resemblance to *A. papilionacea*, Goldf., as developed in the Indian Trichinopoly Group, but the presence of costæ on the body-whorl of the former at once separates the two forms.

A. (?) *Bailyi* is in no way related to *A. coronata*, Tate,[†] of the Uitenhage formation.

GENUS FULGURARIA, *Schumacher*, 1817.

(Essai Nouv. Syst. Hab. Vers Test., 1817, p. 242.)

FULGURARIA, *sp. ind.*

(Pl. III., Figs. 12 and 13.)

Obs.—A fusiform testaceous fragment exhibiting the back of the body-whorl, and indications of some of the posterior whorls appears referable to this genus. The sculpture consists of strong equidistant liræ. It appears to be of the type of *F. elongata*, D'Orb.,[‡] of the Indian Trichinopoly Group.

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[*] Whitfield, Mon. U. S. Geol. Survey, 1892, xviii., p. 119, t. 14, f. 5 and 6.

[†] Quart. Journ. Geol. Soc., 1867, xxiii., p. 152, t. 7, f. 9.

[‡] Stoliczka, Cret. Fauna S. India (Pal. Ind.), 1867, ii., Pts. 1–4, p. 87, t. 7, f. 1–9.

GENUS ZARIA, *Gray*, 1840.

(Synop. Brit. Mus., 1840?; Ed. 1841, p. 125; Proc. Zool. Soc. 1847, Pt. 15, p. 155.)

ZARIA BONEI, *Baily* (?)

(Pl. II., Figs. 28–31; Pl. III., Fig. 9.)

Turritella Bonei, Baily, Quart. Journ. Geol. Soc., 1855, xi., p. 458, t. 12, f. 7.

Turritella multistriata, Griesbach, Quart. Journ. Geol. Soc., 1870, xxvii., p. 64.

Sp. Char.—Shell small, elongate, tapering. Whorls eight to twelve, ventricose, bevelled above and below the sutures; body-whorl convex below. Sutures deep. Aperture oval to round; inner lip produced somewhat below; outer lip insinuated. Sculpture of from three to five revolving liræ, usually three principal, and two or three subordinate, with other finer revolving striæ, subject to variation.

Obs.—This is a small and delicate shell possessing a readily recognisable sculpture. There are primarily three revolving carinæ on each whorl—*a*, one bounding the anterior edge of the suture; *b*, a second at about two-thirds the depth of the whorl from the same point; and *c*, the third at the edge of the posterior suture of each whorl. In some examples two minor carinæ occur between *b* and *c*, and in others a similar keel between *a* and *b*.

Baily described twelve whorls. I have not actually counted more than eight, but none of my specimens are perfect.

Z. Bonei is of the type of *Z. multistriata* (Reuss) Stol,[*] from which it appears to differ hardly at all. Stoliczka compares Baily's *Turritella Meadii*[†] from the Umtafuna beds, with Reuss' species, but it seems to me that the present form is much more closely allied. Mr. C. L. Griesbach appears to have been of a like mind,[‡] for he places *Zaria Bonei* as a synonym of *Z. multistriata*, Reuss, and refers *T. Meadii* to *Chemnitzia undosa* (Sby.), Forbes.

The only point of difference that I can detect between the present South African shell and *Z. Bonei*, Baily, s.p., is that of size. The latter is certainly much larger, whilst all the examples of the former maintain a uniform small size.

GENUS PYROPSIS, *Conrad*, 1860.

(Journ. Acad. Nat. Sci. Philadel., 1860, xii., p. 288.)

PYROPSIS (?), *sp. ind.*

(Pl. III., Figs. 10 and 11.)

Obs.—A single mutilated specimen, with portions of the sculpture preserved, may be tentatively referred to *Pyropsis*. The sculpture consists of strong liræ on the posterior half of the body-whorl, with longitudinal costæ, becoming tuberculate at the points of intersection. Although longer in the canal than *P. cancellata*, J. de C. Sby., sp.,[*] of the Indian Trichinopoly Group, it is not unlike that species, although possibly a more slender form. *Pyropsis Bairdi*, M. and H., sp.,[†] from the Fox Hills Group of the Missouri Cretaceous, may also be advantageously compared.

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[*] Cret. Fauna S. India (Pal. Ind.), 1868, ii., Pt. 5, p. 224.

[†] *Ibid.* p. 226,

[‡] Quart. Journ. Geol. Soc., 1871, xxvii., p. 64.

Genus Patella, *Linnæus*, 1758.

(Systema Nat., Ed. x., 1758, p. 780.)

Patella (?), *sp. ind.*

(Pl. III., Fig. 3.)

Obs.—In this instance again there is only a single specimen. It appears to be a much exfoliated example of a patelliform shell, possibly either *Patella* or *Tectura*. It appears to be of about the same degree of elevation as *Patella caperata*, Tate,[‡] of the Uitenhage formation, but in the absence of sculpture it cannot be safely identified with that species.

Genus Cylichna, *Lovén*, 1847.[§]

(Ofv. K. Vet. Akad. Forhandl., 1846 (1847), p. 142.)

Cylichna Griesbachi, *sp. nov.*

(Pl. III., Figs. 14 and 15.)

Sp. Char.—Shell small, slightly more attenuated anteriorly than posteriorly, but both ends rounded; umbilicoid cavity wide, with the spire completely immersed, but still visible, and the whorls sloping towards the centre. Aperture slightly curved, broader at the anterior than the posterior end; inner lip apparently slightly reflected, with a minute fissure. Sculpture consisting of revolving deeply-cut striæ on the anterior third, and again forming a zone round the posterior edge of the body-whorl, but finer and crossed by microscopic longitudinal riblets, which disappear on the smooth median portion of the body-whorl.

Obs.—This is a small shell resembling those described by Stoliczka as *Cylichna* or *Bullina*,[*] from the Trichinopoly and Arrialoor Groups of Southern India, although, from the infilling of matrix, I cannot detect a plait on the columella. Stoliczka's *Bullinæ* do not appear to me to coincide with the generally accepted characters of that genus, but more closely resemble *Cylichna*. The fact that the sunken spire is visible in the umbilicoidal cavity possibly places this shell even near *Mnestia*, H. and A. Adams.

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[*] Stoliczka, Cret. Fauna S. India (Pal. Ind.), 1867, ii., Pts. 1-4, p. 154, t. 13, f. 1-4.

[†] Meek, Mon. U.S. Geol. Survey (Hayden's), 1876, ix., p. 369, t. 31, f. 10 *a* and *b*.

[‡] Quart. Journ. Geol. Soc., 1867, xxiii., p. 152, t. 7. f 1.

[§] *Non Cylichnus*, Burmeister, 1844.

C. Griesbachi is much too slender a species to be identical with *Actæonina Sharpeana*, Tate,* from the Zwartkop Crag. On the other hand, it closely resembles *Cylichna costata*, Gabb,† met with in the Californian Cretaceous. Named in honour of Mr. C. L. Griesbach, now Director of the Geological Survey of India, who, in 1870, contributed an excellent paper on the Geology of Natal.‡

CYLICHNA FUSULINIFORMIS, *sp. nov.*

(Pl. II., Figs. 33 and 34.)

Sp. Char.—Shell obtusely fusiform, rather stout, much more attenuated posteriorly than anteriorly, but both ends rounded. Umbilicoid cavity very minute, pin-point like; spire immersed and hidden. Aperture slightly curved, decidedly narrower posteriorly than anteriorly. Sculpture consisting of deeply-cut revolving striæ extending over the whole body-whorl.

Obs.—This form is obviously different from the preceding, being separated at once by the pin-point-like nature of the umbilicoid cavity, in fact, the apex is almost closed.

The specific name is derived from its more or less spindle-shaped outline, hence to some extent resembling a *Fusulina.*

GENUS ACTÆONINA, *D'Orbigny*, 1850.

(Prodrome Pal., 1850, i., p. 118.)

ACTÆONINA ATHERSTONEI, *Sharpe*, var. UMKWELANENSIS, *var. nov.*

(Pl. II., Fig. 38.)

Actæon Atherstonei, Sharpe, Trans. Geol. Soc., 1856, vii. (2), Pt. 4, p. 200, t. 28, f. 19.

Actæonina Atherstonei, Tate, Quart. Journ. Geol. Soc., 1867, xxiii., p. 170.

Obs.—A single individual exhibits three whorls, inclusive of the body-whorl, but the anterior portion is enveloped in matrix, so obscuring the apex from view. I cannot see any difference, so far as the shell is preserved, between this and Sharpe's figure of his *Actæon Atherstonei*, except in the sculpture. In the latter the whorls are said to be "ornamented on the lower part" only, whereas in the present instance, the spiral striæ are visible both on the posterior portion of the body-whorl and around the suture also, but on the anterior whorls confined to the sutural zone only. For distinction, therefore, I propose the above varietal name. The variety is also larger than the species proper.

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* Quart. Journ. Geol. Soc., 1867, xxiii., p. 154.

† Pal. California, 1864, i., Sect. 4, p. 143, t. 21, f. 107.

‡ Quart. Journ. Geol. Soc., 1870, xxvii., p. 53.

Genus Gyrodes, *Conrad*, 1860.

(Journ. Acad. Nat. Sci. Philadelphia, 1860, iv. (2), p. 289.)

Gyrodes (?), *sp. ind.*

(Pl. II., Fig. 32; Pl. III., Fig. 1.)

Obs.—Several imperfect specimens are present in the collection, with the globose body-whorl, widely channelled suture, and oblique sculpture lines of this genus. It possessed three or four whorls in all. There is to some extent a resemblance to *Ampullaria* (?) *ignobilis*, Tate,[*] of the Zwarkop Crag, but it is difficult to conceive that the present shell possessed the longitudinally elongated mouth of Tate's species. *Natica multistriata*, Baily,[†] of the Umtafuna and Umzambani beds, does not seem to show the same flattened shoulder round the suture of the body-whorl, as in the present instance.

Genus Chemnitzia, *D'Orbigny*, 1839.

(Webb and Berth., Hist. Nat. Iles Canar., Moll.; *emend.* Pal. Françe Terr. Jurassique, 1851, ii., livr. 65, p. 31.)

Chemnitzia, *sp. ind.*

(Pl. III., Fig. 2.)

Obs.—Two fragmentary specimens appear to indicate the presence of this genus in Mr. Anderson's gatherings. Although smaller, if not identical with, they are closely allied to *C. Sutherlandi*, Baily,[‡] which Griesbach [||] renders synonymous with *C. undosa* (Sby.). Forbes, a member of the Trichinopoly fauna. The specimens now before me seem to represent a shell somewhat too flat on the whorls to be identical with Baily's species, and have a deeper insinuation of the outer lip, as evinced by the sculpture.

Genus Solarium, *Lamarck*, 1799.

(Mém. Soc. Hist. Nat Paris, 1799, p. 74.)

Solarium, *sp. ind.*

(Pl. II., Figs. 35-37.)

Obs.—Two imperfect examples possess the general facies of *Solarium pulchellum*, Baily,[¶] of the Umtafuna and Umzambani beds.

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[*] Quart. Journ. Geol. Soc., 1867, xxiii., p. 153.

[†] *Ibid.*, 1855, xi., p. 460, t. 12, f. 8*a* and *b*.

[‡] *Ibid.*, p. 459, t. 12, f. 5.

[||] *Ibid.*, 1871, xxvii., p. 65.

[¶] *Ibid.*, 1855, xi., p. 457, t. 12, f. 3*a* and *b*.

The regular convexity of the whorls is, however, interrupted by a median depression or concavity, which, on the body-whorl, is midway between its periphery and suture. The sculpture is minutely decussate as in Baily's species.

D'Orbigny employed the trivial name *pulchellum* for a Neocomian *Solarium*,[*] but even anterior to this Michelotti gave the same name to a Falunian species.[†] To avoid confusion Gabb replaced Baily's name by that of *S. Bailyi.*[‡]

3. CEPHALOPODA.

Genus Placenticeras, *Meek*, 1870.

(Proc. Phil. Soc. Philadelphia, 1870, xi., p. 429.)

Placenticeras kaffrarium, *sp. nov.*

(Pl. III., Fig. 16.)

Obs.—This is a portion of an Ammonite of medium size, with very distant, wide ribs, each with a small tubercle above the umbilicus, and a tumid, blunt, low tubercle on the centre of the flank. It is a discoid form, and generally compressed, with a narrow and flat venter, and a series of very small nodes along each edge, crenating it. The umbilicus is telescopic, showing only small portions of the inner whorls. The sutures are faintly visible on portions of the flanks, and appear to have a ragged outline, but not so intimately divided as in *Placenticeras placenta*, De Kay, sp., the type of the genus. The longest diameter is four and a half inches, the transverse diameter (as preserved) three inches, and the thickness one and a quarter inches. The umbilicus is one inch in diameter, and the width of the venter two-eighths of an inch.

The crenating nodes along the edges of the venter resemble those in a similar position on *P. syrtalis*, Morton,[§] and *P. guadaloupæ*, Stol. (*non* Roemer).[||]

Placenticeras kaffrarium is quite distinct from any other Ammonite figure from South Africa, and, although fragmentary, I venture to bestow on it the above name.

Placenticeras umkwelanensis, *sp. nov.*

(Pl. III., Figs. 17–20.)

Sp. char.—Shell lenticular, small; transverse section trigonal-sagittate; whorls deeply embracing, the older almost hidden by the younger, compressed laterally; flanks flattened, convergent; umbilicus very small, slightly telescopic. Venter very narrow and truncate, flat or slightly concave, the abdominal edges sharp: dorsum deeply excavate. Siphuncle comparatively large. Septa with about twelve lateral lobes on each side, with prominent and narrow intervening saddles. Sculpture of fine sigmoidal lines: no tubercles, &c.

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[*] Prodrome Pal., 1850, ii., p. 104.

[†] *Ibid.*, 1852, iii., p. 45.

[‡] Proc. American Phil. Soc., 1861, viii., p. 95.

[§] *P. placanta*, var. *intercalare*, Meek, Report U.S. Geol. Survey Territories (Hayden's), 1876, ix., t. 23, f. 1*a* and *b*.

[||] Foss. Cephalopoda Cret. Rocks S. India (Pal. Ind.), 1864, Pt. 4, t. 47, f. 2.

Obs.—This little Ammonite is quite of the type of *P. placenta*, De Kay, from the Greensand Marls of New Jersey, and the type of the genus *Placenticeras*. The surface is quite plain, and devoid of tubercles, such as ornament the flanks of *P. syrtalis*, Morton. The suture details are not preserved.

Genus Creniceras, *Munier-Chalmas*.

(Dall in Zittel-Eastman, Text Book Pal., 1890, i., p. 569.)

Creniceras (?), *sp. ind.*

(Pl. III., Figs. 21 and 22.)

Obs.—A very small Ammonite, more or less embedded in matrix, but with a longitudinal diameter of seven millimetres. On the flanks are single faint distant costæ, terminating at the abdominal angles in small tubercles. The venter is sharp and bears small projecting tubercles, giving rise to an undulating peripheral outline: these are midway between each pair of abdominal tubercles, and are low and cristiform.

Creniceras Reuggeri, Oppel,[*] an Oxfordian species, is the only ally I have so far succeeded in finding.

Genus Hamites, *Parkinson*, 1811.

(Organic Remains, 1811, iii., p. 144.)

Obs.—A fragmentary fossil (Pl. III., Fig. 23) of doubtful identity, either *Hamites* or *Anisoceras*. It possesses horizontal costæ, unlike those of *H. africanus*, Tate,[†] of the Uitenhage formation. If an *Anisoceras*, it is similar to that termed by Griesbach, *A. rugatum*, Forbes,[‡] from the Umtafuna beds.

Genus Baculites, *Lamarck*, 1799.

(Mém. Soc. Hist. Nat., Paris, 1799.)

Obs.—A partly exfoliated smooth fragment (Pl. III., Fig. 24), just sufficient remaining to prove the presence of yet another Cephalopod in these beds. There is no trace of the sulcations visible on the surface of *B. sulcatus*, Baily,[*] from the Umtafuna beds. From the absence of costæ, it might even be a portion of a *Ptychoceras*.

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[*] Dall, *loc. cit.*, p. 569, f. 1178.

[†] Quart. Journ. Geol. Soc., 1867, xxiii., p. 150, t. 7, f. 5*a*–*d*.

[‡] *Ibid.*, 1871, xxvii., p. 63, t. 3, f. 4.

4. PISCES.

Obs.—The remains of Fish are indicated by the presence of two fragmentary *Lamna* teeth (Pl. III., Fig. 25), of the *Lamna appendiculata* type, indicating the presence of a Shark in the Umkwelane beds.

I also figure a spine (Pl. III., Fig. 26), the only one represented in the collection, and which I have not been able to determine.

III.—GEOLOGICAL RESULTS.

In the foregoing pages I have endeavoured to demonstrate the existence in the Umkwelane Hill shell-agglomerate of at least thirty-seven species of Mollusca, either as definite specific forms, capable of future recognition, or, as indicated forms, that are certainly distinct from those in the same category, although not sufficiently perfect to warrant the attachment of specific names. These are distributed as follows:—

Pelecypoda	21
Gasteropoda	11
Cephalopoda	5
	37

Very divergent views are entertained by authorities on the age of the various sub-divisions of the South African Mesozoic Series, but the trend of opinion seems to be to regard the whole, from the Uitenhage formation upwards, as Cretaceous. It is not my intention to enter on a discussion of so wide a subject, but those interested in the question will find a summary in a paper "On the Occurrence " " of *Alectryonia ungulata*, in S.E. Africa; with a Notice of previous " " researches on the Cretaceous Conchology of Southern Africa," by Mr. R. B. Newton.[†]

The view adopted by Dr. Franz Kossmat,[‡] one of the latest, if not the latest writer on the subject, and who has compared the South Indian Cretaceous with that of South Africa and other world-wide areas, is expressed in the following table of the South African Cretaceous. It is taken from both Dr. Kossmat and Mr. Newton's papers, but with the addition of the local terminology and the stratigraphical subdivisions given by Griesbach.[¶]

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[*] Quart. Journ. Geol. Soc., 1855, xi., p. 457, t. 11, f. 5*a–c*.

[†] Journ. Conch., 1896, viii., No. 5, p. 136 (Summary, p. 147).

[‡] Jahrb. k. k. Geol. Reichsanstalt, Wien, 1894, xliv., 3 and 4 Hefts, p. 459.

[¶] The stratigraphical sub-divisions of Kossmat's table are virtually the same as those previously published by Mr. C. L. Griesbach (Quart. Journ. Geol. Soc., 1871, xxvii., p. 62).

UPPER CRETACEOUS.

S. African Local Sub-divisions.	S. African Sub-divisions of Griesbach,* &c.	Indian Equivalents.	European Equivalents.
Umtafuna or Umzambani Beds (*Baily*). = Izinhluzabalungu Deposits (*Griesbach*). Umtamfunaschichten (*Schenck*).	*a.* Chalk ("hard limestone") with *Puzosia Gardeni*, Baily, sp. *b.* Sandstone and grit, with "many fossils," mostly bivalves and univalves. *c.* Sandstones and grits, with *Schloenbachia umbolazi*, Baily, sp.; *S. Soutoni*, Baily, sp.; *S. Strangeri*, Baily, sp.; *Anisoceras rugatum*, Forbes, &c. *d.* Soft brown sandstone, with *Trigonia Shepstonei*. *e.* Chalky sandstone, with *Teredo*-bored wood.	Arrialoor Group. Trichinopoly Group. Ootatoor Group.	*Senonian*, or Upper Chalk. *Turonian*, or Lower Chalk. *Cenomanian*, or Chalk Marl, Chloritic Marl, Upper Greensand, and Gault.

LOWER CRETACEOUS (NEOCOMIAN).

Uitenhage Formation (S. Africa).

It will be seen by a glance at Table A that I regard three species of Pelecypoda as identical, to all intents and purposes, with an equal number from the South African Upper Cretaceous; two others represented by allied forms in the same formation, and two Gasteropods, whilst one bivalve and one univalve appear to possess allied species in the South African Lower Cretaceous.

TABLE A.

Species, occurring elsewhere, allied to certain of those described in this paper.

Umkwelane Hill Species.	Allied Species.	Horizon.
Trigonarca umzambaniensis, *Baily*.	T. abrupta, *Forbes*.	Trichinopoly Group, India.
Cytherea Kaffraria, *Mihi*.	C. sculpturata, *Stol.*	Arrialoor Group, India.
Eriphyla lenticularis, *Goldf.*	E. lenticularis (*Stol*), *Goldf.*	Trichinopoly Group, India.
„ (?) Rupert-Jonesi, *Mihi*.	E. Stuhlmanni, *Müller*.	Neocomian of German East Africa.
Cardium Bullen-Newtoni, *Mihi*.	C. (Acanthocardium) pullatum, *Stol.*	Trichinopoly Group, India.
Protocardium hillanum, *Sby.*, *var.* umkwelanensis, *Mihi*.	P. hillanum (*Sby.*), *Stol.*	„ „ „
Donax Andersoni, *Mihi*.	D. latus, *Gabb*.	Tejon Group, California.
Mactra zulu, *Mihi*.	M. gracilis, *Meek* and *Hayden*.	Fort Pierre Group.
	M. nitidula, *Meek* and *Hayden*.	Foxhills Group.
Alaria (?) Bailyi, *Mihi*.	A. papilionacea (*Goldf.*), *Stol.*	Trichinopoly Group, India.
Pyropsis, *sp. ind.*	P. cancellata, *J. de C. Sby.*	„ „ „
	P. Bairdi, *Meek* and *Hayden*.	Foxhills Group.
Cylichna Griesbachi, *Mihi*.	C. costata, *Gabb*.	Chico and Tejon Groups, California.
Chemnitzia, *sp. ind.*	C. undosa (*Sby.*), *Stol.*	Trichinopoly Group, India.
Fulguraria (?), *sp. ind.*	F. elongata (*D'Orb.*), *Stol.*	Trichinopoly and Arrialoor Groups, India.
Zaria Bonei, *Baily*.	Z. multistriata (*Ruess*), *Stol.*	Trichinopoly and Arrialoor Groups, India.
Placenticeras umkwelanensis, *Mihi*.	P. placenta, *De Kay*.	Greensands of New Jersey.

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* In descending order.

From Table B it will be apparent that as regards exotic alliances, the Trichinopoly Group, and to some extent the Arrialoor Group also, of Southern India, claim a fair proportion of those that can be satisfactorily made out, thus :—

	Pelecypoda.	Gasteropoda.
Trichinopoly Group	4	5
Arrialoor „	1	3

TABLE B.

Principal Species believed to be identical with, or closely related to, already described South African forms.

UMKWELANE HILL SPECIES.	ALREADY DESCRIBED SOUTH AFRICAN SPECIES.	HORIZON.
Exogyra, *sp. ind.*	Ostrea (Exogyra) jonesiana, *Tate* + Placunopsis imbricata, *Tate.*	Uitenhage Formation.
Trigonarca umzambaniensis, *Baily.*	T. umzambaniensis, *Baily.*	Umtafuna Beds.
Latiarca natalensis, *Baily.*	L. natalensis, *Baily.*	„ „
Protocardium hillanum, *Sby*, *var.* umkwelanensis, *Mihi.*	P. hillanum, *Sby.*	„ „
Actæonina Atherstonei, *Sharpe*, *var.* umkwelanensis, *Mihi.*	A. Atherstonei, *Sharpe.*	Uitenhage Formation.
Chemnitzia, *sp. ind.*	C. Sutherlandi, *Baily* (= C. undosa, *Sby*).	Umtafuna Beds.
Solarium, *sp. ind.*	S. pulchellum, *Baily.*	„ „

Puzosia Gardeni, Baily, sp., has not been observed in the present collection, nor any of the Ammonites mentioned as occurring in Griesbach's stratum *c*, nor *Teredo*-bored wood as in *e* of the same author. The fauna of the Umkwelane Hill Deposit consists, with few exceptions, of bivalves and univalves, like that of Griesbach's stratum *b*, and some of the species are identical with those met with in the latter. There appears to be a close connection between the fossils of the two beds, possibly they may actually be on the same horizon.

I do not trace any resemblance between these fossils and those forming the Australian Cretaceous fauna.

REPORT

ON COLLECTIONS OF NATAL FOSSIL PLANTS

FROM

I. THE ECCA COAL SERIES OF UMHLALI ON THE NORTH-EAST COAST OF NATAL.

II. THE DRAKENSBERG RANGE IN WEST NATAL.

By A. C. SEWARD, Esq., F.R.S., &c.,
University Lecturer in Botany, Cambridge, England.

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I.—UMHLALI PLANTS.

The great majority of the specimens consist of fragments of *Glossopteris* leaves, which are only in rare cases sufficiently well preserved to enable one to make out the form and venation of the fronds. A few of the leaves agree closely with specimens described by Feistmantel and other authors as species of *Gangamopteris*, but as Etheridge * has pointed out, it is often almost impossible to draw a satisfactory line between *Glossopteris* and McCoy's genus *Gangamopteris*.

A few imperfect fragments of an Equisetaceous plant, probably *Schizoneura*, occur in association with its *Glossopteris* fronds.

Genus Glossopteris, *Brongniart.*

(Prodr. Hist. Vég. Foss., p. 54, 1828. Hist. Vég. Foss., p. 222, Pls. LXII., LXIII., 1828.)

This genus of ferns has undoubtedly been divided into a greater number of species than the available evidence justifies. In the majority of cases *Glossopteris* is represented by isolated and often fragmentary leaves detached from the stem, and in none of the numerous specimens of this genus from India, Australia, or Africa have trustworthy traces of sporangia been found. Until we have better evidence to guide us it is useless to speculate on the affinities of the plant; the form of the frond and such characters of the rhizome as are known invite a comparison with recent Polypodiaceous ferns, but on this point further evidence is urgently needed. It is at least clear that *Glossopteris* was an exceedingly abundant and widely spread type in the southern hemisphere and in India; the occurrence of numberless leaves over a wide area in the plant-beds of South Africa, India, and Australia shows that this fern monopolised large tracts of land in a manner comparable to the ubiquitous Bracken Fern (*Pteris aquilina*). Attention has been called by Zeiller,[*] Etheridge,[†] Potonié,[‡] and others to the variation, as regards both form and venation, in the fronds of *Glossopteris*. It is indeed practically impossible to give specific diagnoses which may serve as indices of well-defined differences; as I have elsewhere urged,[§] all that we can do is to select a dominant form round which to group such fronds as exhibit a more or less well-marked departure from the central type.

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* Etheridge (94), p. 240.

Glossopteris Browniana, *Brongn.*

(Hist. Vég. Foss., p. 223, Pl. LXII., 1828.)

(Pl. IV., Figs. 1–7.)

Our knowledge of this type has been extended in recent years by Zeiller's demonstration[||] that Royle's Genus *Vertebraria* is the rhizome of *Glossopteris*, a conclusion confirmed by Oldham[¶] and Arber.[**] It is also clear that the comparatively large tongue-shaped *Glossopteris* fronds were in some cases associated on the same plant with small scale-leaves characterised by the absence of a midrib.

A.—Fronds.

The form of frond designated *Glossopteris Browniana* cannot, I believe, be distinguished from Schimper's species *Glossopteris indica*, and there is no doubt that several of Feistmantel's Indian species—*e.g.*, *G. intermittus*, *G. decipiens*, *G. communis*, var. *stenoneura*, &c.—should not be regarded as specifically distinct from Brongniart's type, *Glossopteris Browniana*.

The leaf represented in Fig. 1 may be taken as an example of the type-form of *Glossopteris Browniana;* it has a length of 11 cm. and a breadth of 2·3 cm. There is a well-marked midrib from which numerous secondary veins, characterised by frequent anastomoses, arch obliquely outwards to the margin of the lamina.

In addition to several scale-leaves, which are described below, a few small fronds are met with in association with those of normal size, which agree very closely with examples described by Zeiller,[††] and regarded by that author as leaves of young and partially developed plants.

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[*] Zeiller (96), p. 363.
[†] Etheridge (94), p. 240.
[‡] Potonié (00), pp. 2, 4.
[§] Seward (97), p. 316.
[||] Zeiller (96).
[¶] Oldham (97).
[**] Arber (02).
[††] Zeiller (96), pl. 16, fig. 1.

GLOSSOPTERIS BROWNIANA, *var.* INDICA.

(Pl. IV., Fig. 2.)

Under this head may be included several larger forms apparently identical with fronds described by Feistmantel[*] from the Talchir, Karharbari and Damuda beds of India, and referred by him to *Glossopteris communis* and other species. The difficulty of distinguishing between the genera *Glossopteris* and *Gangamopteris* is illustrated by an inspection of Feistmantel's drawings in his "Fossil Flora of the Lower Gondwanas." In some of the fronds figured by this author as *Gangamopteris cyclopteroides* the median part of the lamina is occupied by a few vertical veins which may be said to constitute a midrib; between leaves of this type and others described as species of *Glossopteris* no real distinction can be drawn.[†] Among the Umhlali specimens there are no large fronds which can be described as conforming to the recognised definition of *Gangamopteris.* The specimen shown in Fig. 2, 15 cm. long and 6 cm. wide at the broadest part of the lamina, agrees in essentials with the smaller frond represented in Fig. 1 as a typical example of *G. Browniana.* In the larger fronds, especially in a specimen (415), slightly broader than that shown in Fig. 2, the lateral veins are very numerous and separated from one another by narrower meshes than in the smaller fronds of *G. Browniana.* The leaf described by myself from the neighbourhood of Johannesburg[‡] as *Glossopteris Browniana,* var. *indica* is no doubt identical with that shown in Fig. 2.

GLOSSOPTERIS BROWNIANA, *var.* ANGUSTIFOLIA, *Brongn.*

(Pl. IV., Figs. 3, 4.)

The narrower type of leaf, originally described by Brongniart as *Glossopteris angustifolia,*[§] cannot, I believe, be separated as a distinct species from *Glossopteris Browniana.* The long and narrow fronds from Central India, described by Bunbury in 1861[||] as *G. leptoneura* and *G. stricta,* which may also be included under the above designation, also the Australian leaves which McCoy named *Glossopteris linearis.*[¶]

Fig. 3 illustrates the larger form of this type of frond; the specimen measures 23 cm. in length and 3 cm. in breadth; it is impossible to make out the venation, but in all probability the lateral veins were similar to those in the smaller leaf shown in Fig. 4.

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[*] Feistmantel (79), (81).

[†] *Ibid.* (79), *passim.*

[‡] Seward (97), pl. 21, fig. 3.

[§] Brongniart (28), pl. 63, fig. 1.

[||] Bunbury (61), pl. 9.

[¶] Arber (02), and McCoy (42), pl. 9.

Bunbury's *Glossopteris stricta* and some of the leaves included by Feistmantel in *G. communis* appear to be identical with this South African form.[*]

The smaller leaf, Fig. 4, is 6·5 cm. long and 1·4 cm. broad; it agrees with fronds described by Feistmantel from Lower Gondwana rocks as *Glossopteris angustifolia.* Both the midrib and lateral anastomosing veins are clearly shown, agreeing with the venation characters of the typical *G. Browniana.*

B.—SCALE-LEAVES (*Glossopteris Browniana*).

(Pl. IV., Figs. 5, 6.)

In 1847 McCoy[†] drew attention to the occurrence of small ovate scales in connection with the rhizome of *Glossopteris Browniana;* similar scales have been figured by Zeiller,[‡] and myself,[§] and Mr. Arber[||] has recently redescribed McCoy's specimens. There can be little doubt that *Glossopteris Browniana* bore on its rhizome both its normal tongue-shaped foliage-leaves and small scale-leaves characterised by their size and by the absence of a midrib. It is impossible to distinguish in all cases between young fronds or the fronds of miniature plants and the scale-leaves from an adult rhizome, but the example shown in Fig. 6, which agrees closely with specimens figured by Zeiller,[¶] may be taken as a typical scale-leaf of *G. Browniana.* The lamina is 2·5 cm. long by 2 cm. broad; the veins are clearly shown spreading obliquely outwards and frequently anastomosing.

The specimen represented in Fig. 5 is probably another scale-leaf, while that shown in Fig. 7 is possibly an ordinary foliage-leaf of small size, almost identical with one figured by Zeiller,[**] and very similar to a small leaf described by Feistmantel[††] from the Indian Talchir beds as *Gangamopteris cyclopteroides*, var. *attenuata.*

C.—STEMS.

The collection contains a few specimens of *Glossopteris* rhizome, fossils formerly known as *Vertebraria;* but these exhibit no features worthy of remark.

LEAF OF DOUBTFUL AFFINITY.

NOEGGERATHIOPSIS (?) *sp.*

(Pl. IV., Fig. 8.)

The leaf shown in Fig. 8, 3·5 cm. by 2·2 cm., has a bluntly rounded apex, which appears to be complete; the lamina is traversed by numerous spreading dichotomous veins, between which I have not been able to recognise any cross-connections. The specimen may be compared with one figured by Zeiller[*] as *Noeggerathiopsis Hislopi* and with a single leaf from the Karharbári beds of India, described by Feistmantel under the name *Glossozamites Stoliczkianus;*[†] Feistmantel's *Noeggerathiopsis prisca,*[‡] from New South Wales, bears a close resemblance to the Natal specimen. It is not improbable that Feistmantel's specimen should also be placed in the genus *Noeggerathiopsis.* The apparent absence of anastomoses between the veins and of a midrib leads me to regard the leaf as probably that of *Noeggerathiopsis;* but the material is insufficient to enable me to speak with confidence as to systematic position.

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[*] See also Seward (97), pl. 21, fig. 4A.

[†] McCoy (47).

[‡] Zeiller (96).

[§] Seward (97).

[||] Arber (02).

[¶] *Loc. cit.* pl. 16, figs. 9–14.

[**] Zeiller (96), pl. 16, fig. 3.

[††] Feistmantel (79), pl. 10, fig. 5.

Schizoneura (?)

There are several fragments of Equisetaceous stems, with clearly marked longitudinal ribs and grooves which pursue a straight course from one internode to the next; but in the absence of well-preserved leaves the distinction between *Schizoneura* and *Phyllotheca* can hardly be recognised. Similar specimens have been described by several writers; a comparison may be made with Feistmantel's stems from India[§] and with a specimen figured by myself from South Africa.[||] Associated with some of the Umhlali stems occur fragments which may be the remains of narrow *Schizoneura* leaves.

Age of the Umhlali Beds.

Owing to the small number of species that it is possible to determine, any opinion as to the geological horizon indicated by the plants must be expressed with reserve. *Glossopteris Browniana* is exceedingly abundant; *Noeggerathiopsis* is possibly represented, and stems, doubtfully placed in the genus *Schizoneura,* are fairly plentiful. No undoubted *Gangamopteris* has been recognised. On the whole the evidence would appear to support the view that the plant-beds are approximately homotaxial with the Damuda Beds of India, and belong to the Beaufort Series of South Africa.

II.—DRAKENSBERG PLANTS.

Thinnfeldia Odontopteroides (*Morr.*).

This species is represented by some particularly well-preserved specimens, in which the venation of the entire and more or less lobed pinnules is clearly shown. The plant is certainly identical, so far at least as external form, with that figured by Feistmantel [*] from Cape Colony. The species is an abundant member of the Mesozoic plant-beds of South Africa.

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[*] Zeiller (96), pl. 18, fig. 6.

[†] Feistmantel (79), pl. 20, figs. 4 and 5.

[‡] *Ibid.* (90), pl. 13, fig. 2.

[§] *Ibid.* (79).

[||] Seward (97), pl. 24, fig. 1.

PTEROPHYLLUM, *sp.*

Cf. *P. Footeanum*, Feist., and *P. Rubidgei* (Tate).
(Pl. V., Fig. 9.)

The piece of pinnate Cycadean frond shown in Fig. 9 consists of a fairly stout axis to which linear pinnæ are laterally attached; the pinnæ are slightly constricted at the base, and separate from one another by a distance approximately equal to the breadth of the segments, none of which are complete. The venation (Fig. 9a) consists of several slightly spreading and dichotomous veins, usually forked as they enter the lamina. In the lateral attachment of the pinnæ and in general habit the frond conforms to the Genus *Pterophyllum:* it is often difficult to determine how far the apparent lateral attachment is due to the fact that the pinnæ and rachis are seen from below, but in this case the preservation is good, and I feel confidence in describing the pinnæ as lateral. The specimen figured by Tate [†] as *Palæozamia Rubidgei*, from the Geelhoutboom Series of Africa, is possibly identical with the Natal species; similar or identical fronds have been figured by Feistmantel from Upper Gondwana rocks of India, *e.g.*, *Pterophyllum Kingianum*, Feist.; [‡] *P. Hislopianum*, Old. and Morr.; [§] *P. Morrisianum*, Old.; [||] *P. Carterianum*, Old. and Morr.; [¶] and more especially *P. Footeanum*, Feist. [**] A specimen from the Ipswich beds of Queensland, described by Jack and Etheridge as *Pterophyllum*, sp. ind., [††] also closely resembles the Natal fragment. Perhaps Tate's specimen and those named by Feistmantel *Footeanum* are the most nearly allied to the example shown in Fig. 9; it is not unlikely that the resemblance may amount to specific identity, but until larger pieces are found it would be unwise to do more than suggest the probability of identity.

PLANT OF DOUBTFUL AFFINITY.

(Pl. V., Figs. 10, 11, and 11a.)

The specimens shown in Figs. 10 and 11 may be compared with both Cycads and Conifers; the smaller example (Fig. 11) is very similar to various species of *Taxites*, *Palissya*, and other genera, while the larger piece (Fig. 10) bears a close resemblance to a Cycad frond with narrow pinnæ. The central axis is, however, more slender than we should expect if the plant were a Cycad; in both fossil and recent forms the rachis of a Cycad frond is stout and relatively thick. The axis is fairly stout and woody in appearance. The long and narrow lateral members are also comparatively strong and stiff; it is not easy to decide whether each appendage is traversed by one central vein or whether the midrib-like character seen in some parts of the specimens is merely the result of preservation or of the form of the appendages. As an instance of the difficulty of recognising the presence of several veins in a narrow pinna reference may be made to the Wealden Cycad, *Dioonites Dunkerianus* (Goepp.).[*] The apex of each appendage terminated in an acuminate tip (Fig. 11a). There are various published figures which agree more or less closely with Figs. 10 and 11; these represent species described by authors as conifers, cycads, and ferns. It is clearly impossible to decide with any confidence to which class the Natal fragments should be relegated, but I prefer to regard them as portions of a gymnospermous plant rather than fragments of a fern. The small specimen figured by Szajnocha[†] from the Argentine as *Sphenopteris elongata*, Carr., resembles that shown in Fig. 10; but the drawing of Carruthers' type-specimen[‡] does not appear to me to justify Szajnocha's determination. An imperfectly preserved fragment figured by McCoy as *Pecopteris* (?) *tenuifolia*[§] from New South Wales bears a close resemblance to the African species, but in this case also there is not sufficient reason for the choice of a Fern Genus. Species of *Frenelopsis* may be compared with the fossil shown in Fig. 10, but the absence of any scale-leaves is not in accord with the characters of this genus. Examples of Potomac plants, referred by Fontaine[||] on insufficient evidence to *Sequoia*, afford another possible comparison. Another plant which appears to be very similar to the imperfect specimens from Natal is *Bechlesia anomala*,[¶] founded on material of Wealden age from the Sussex coast. We must leave this type as one of uncertain position, but with the suggestion that it is probably gymnospermous rather than filicinean.

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[*] Feistmantel (89), pl. 1.

[†] Tate (47), pl. 5, fig. 3.

[‡] Feistmantel (77), pl. 4.

[§] Oldham and Morris (63), pl. 9.

[||] Feistmantel (77), pl. 6.

[¶] *Ibid.* (77), pl. 3.

[**] Feistmantel (79^2), pl. 6.

[††] Jack and Etheridge (92), pl. 16.

Age of the Drakensberg Plants.

There can be no doubt that the few available specimens point to an horizon considerably above that of the Umhlali plant-beds. On the whole it would seem probable that the age indicated by *Thinnfeldia* and *Pterophyllum* is approximately Rhætic or Lower Jurassic.

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[*] Seward (95), pl. 3.

[†] Szajnocha (88), pl. 2, fig. 2.

[‡] Carruthers (72), pl. 27, fig. 1.

[§] McCoy (47), pl. 9, fig. 6. See also Arber (02), p. 3.

[||] Fontaine (89), pls. 112, 117.

[¶] Seward (95), pl. 14.

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PRELIMINARY REPORT

ON THE

GEOLOGY OF THE NEIGHBOURHOOD OF DURBAN.

PRELIMINARY REPORT ON THE GEOLOGY OF THE NEIGHBOURHOOD OF DURBAN, WITH SPECIAL REFERENCE TO THE POSSIBILITIES OF OBTAINING PAYABLE COAL UNDER THE BLUFF.

The principal business quarter of Durban City is situated on the flat ground bordering the northern and western shores of the bay. The chief residential area is, however, on the Berea, a long north and south ridge about 300 feet in height and lying nearly a mile to the west of the city. The bay is protected from the ocean by the Bluff and the sandy-covered ridge, which, near Isipingo connects it with the mainland. The point of the peninsula known as the Bluff, upon which the lighthouse is situated, is not of any great width, and its height is not considerable. Its geological structure is, however, different from anything else we have on the coast, from the Cretaceous rocks of St. John's river to the Cretaceous rocks to the north of the Umhlatuzi lagoon in Zululand. In fact, the rock, which forms, at the surface, the backbone of the Bluff, and a portion of the ridge connecting it with the mainland, is certainly younger than anything exposed between the above limits. It is a calcareous sandstone, showing false bedding, and probably forms some part of the Cretaceous Series. The connecting ridge is so overgrown with small timber and undergrowth that rock-outcrops are of rare occurrence. In the near future, however, when the necessary clearing of the timber has taken place, for the throwing open of this ridge as a residential area, we may expect to find outcrops of rock which will be of great geological value. On some parts of this ridge the sands have a peculiar dark chocolate colour, which is characteristic of many local areas of sand dunes along the northern coast of Natal, and as far north on the coast of Zululand as I have been. In a few isolated cases the chocolate colouring can quite logically be explained by the presence in the near neighbourhood of basaltic rocks through whose denudation the necessary ferruginous material has been produced to colour the sand grains forming the local sand dunes. This explanation does not, however, account for the colouration of all the chocolate-coloured sand dunes which occur along the east coast. It would seem to me from the large area over which this colouration occurs that its cause was not of a local character, but the result of some outside influence. In no case does the colouration of the sand occur any distance inland; it is usually confined to the high sand dunes forming the coastal ridge. Where the colouring matter is present the ferruginous material has formed a cement which has bound the sand grains together and formed a hard sandy rock almost approaching a ferruginous sandstone. A curious point in reference to these deposits is the presence (certainly locally) of isolated pebbles and collections of pebbles, chiefly rounded and waterworn among the hard ferruginous sands; in fact, on many surfaces which the wind has worn bare, it is quite remarkable to see the collection of rounded pebbles, mostly consisting of metamorphic quartzites, jasperoid rocks, and others, in a locality where no outcrops of such formations occur within long distances, which have accumulated on these surfaces through gravitation, their enclosing sand grains having been scattered by the wind. This is not characteristic of the low-lying coast sands, but is of common occurrence at an elevation of hundreds of feet above sea-level.

A large portion of the bay is very shallow, and at low water extensive mud and sandy flats are visible, particularly on its south-western side. These mud flats are cut through by channels which connect the mouths of the various rivers entering the bay, with the deeper parts of the harbour near the sea entrance. At the south-eastern side a considerable area is occupied by islands, which are always above high-water mark, and are covered with mangroves and other trees and shrubs. With the gradual silting up of the bay by the *débris* from the rivers and the imperceptible elevation of the coast, these islands are being naturally reclaimed, although slowly, and in the future they will doubtless be of great importance in the development of the bay by furnishing additional facilities for wharfage. As they are already connected at low water with the eastern shores of the bay, between the Bluff and Wentworth, by a muddy bank, this would afford a very easy means of connecting the islands with the mainland for the purposes of railway and other traffic.

The Durban flats, on which the town is built, have been chiefly formed by the detritus carried into the bay by the various rivers which flow into it, the Umhlaluzana and Umbilo rivers, largely assisted by the wind-blown sands from along the coast. The Umgeni river, which now flows directly into the sea some miles to the north of the entrance to the Bay, has in previous times undoubtedly largely contributed to the formation of the northern and western portions of the flats. In fact, within the memory of some of the oldest inhabitants, during the floods in April, 1856, the Umgeni river, or at least a large branch of it, was deflected southwards from below the Umgeni bridge, and flowed over the flats behind the Back Beach sandhills, entering the Bay by the channel where the Point joins the mainland, thus forming a delta with the present sea opening. It was along this old channel that in 1850 a proposal was made to form a canal by means of which the waters of the Umgeni river were to be diverted into the Bay to help to produce the scouring effect, necessary to clean out that part of the Bay at which it entered. This idea, however, has never been adopted, and it is now practically at the point of exit of this old channel at which the new dry dock is to be situated, The deposits forming the flats are similar petrologically to those now being deposited in the bay and exposed at low water. They consist chiefly of alternating layers of sand and clay, with occasional beds of shell-marl, usually of local distribution. The surface deposits of the reclaimed areas almost always consist of muds, and this is characteristic of almost all estuarine superficial deposits which are above low-water mark. Such muddy estuarine deposits are naturally of a very fertile nature from an agricultural point of view, although in the neighbourhood of Durban Bay these reclaimable areas (it seems almost a reflection on the farmer to say so) will be much more valuable as residential and business areas. There are, however, other estuarine areas, both in Natal and Zululand, where the above holds good. The mineral matters forming these deposits are in the form of clays and sands, chiefly the former. Within the tidal area these become mixed with large quantities of organic matter, besides the usual errant vegetable remains, because the fresh water flowing from the rivers contains enormous quantities of minute animal organisms, which are immediately killed when they come in contact with the salt water. The same is the case with the minute marine organisms which crowd the sea water, they die on contact with the fresh water; so that within the tidal area, particularly where this is of considerable lateral extent, large areas of reclaimed land can be obtained of the most valuable quality for agricultural purposes.

The reason why such estuarine deposits consist so largely of clay or mud is that not only do the finer particles in suspension in the fresh water of the rivers or creeks consist of minutely comminuted quartz and clayey material, but much of the latter is in a colloid form, and this is precipitated in the tidal area immediately on contact with the salt water, and is necessarily deposited over that area. The result is the formation of reclaimable land which in most cases is of a most reproductive character. Instances of good agricultural land of estuarine origin are innumerable: the Carse lands of Scotland; the Slob lands of Ireland; the Dutch Polder of the Netherlands; and the English estuarine deposits of the principal rivers, at the mouths of the Humber, Severn, the Wash, and the Thames.

Through the kindness of Mr. C. J. Croft, the harbour engineer, I was enabled to examine samples of the material taken at a depth in the various bores put down in the bay for the new dry dock near the Cold Storage Company's buildings. These correspond closely with the deposits exposed in any bore or section on the flats. Through information received from Mr. G. B. Laffan, I visited the cuttings at the South Coast Junction and near Wentworth, where deposits of shell marl were exposed in the cutting of the canals into the bay. In both cases the shell marl occurs just below high-water mark, and is covered by about 4 feet of sands and carbonaceous clay containing a large amount of vegetable matter, with tree stumps, &c. The shells are all of Recent species now living in the bay. One of the exceptional points in reference to them is the large quantities of oyster shells which occur in the shell layers at South Coast Junction. The occurrence of these shelly deposits is as a rule local, and in some localities they are in sufficient quantity to be used for the production of lime. On the Congella flats a similar deposit, at a higher level than the one mentioned above, and on the present surface, has provided the material for the burning of lime for quite a number of years.

On examining the specimens obtained from the cuttings above mentioned, Mr. Burnup informed me that at least one species of Gasteropod was only known on the Natal coast from shell specimens picked up in the neighbourhood of Congella, no fresh examples of the species having as yet been obtained anywhere along the coast. Some of these shell specimens were in a remarkable state of preservation, the colouring and the nacre still being prominently fresh, showing that they had been in the live state at no very ancient date. It is more than probable that live specimens of these species will yet be found in some of our estuaries along the coast.

The flats are fringed along the coast with low sand dunes, which, as a rule, are covered with stunted bush, but on this part of the coast, do not attain to any great height. The wind-blown sands, forming these dunes, cover the whole country for some miles inland to such an extent that outcrops of rock are rare indeed. The main ridge of the Berea, except its northern and southern ends, is entirely covered with a great depth of sand, and so also is the peninsula of the Bluff. In each case, however, there is no doubt that the backbone of the ridge is of rock; glacial Ecca Conglomerate in the one case and a much more recent calcareous sandstone (probably Cretaceous) in the other; although in this latter case it is just possible that in the neighbourhood of Wentworth the rocks may be Table Mountain Sandstones. This formation is present on the flat to the west, both *in situ* at the Durban to Umlazi road, and occurs as large boulders in the alluvial deposits quite close to the lower part of the Bluff ridge near Jacob's railway station, on the Bluff line.

Berea

The northern boundary of the Durban flats is immediately to the north of the mouth of the Umgeni river, where the alluvial gives place to the outcrop of glacial Ecca Conglomerate, which forms the undulating country along the coast. In the Inanda Division, to the north-west the country becomes much broken, precipitous, and rugged, as you pass over the Table Mountain Sandstones on to the Granitic and Metamorphic Series. Not far above the Umgeni bridge, on the northern side of the river, is Sea Cow lake, which, in the early days of the settlement, was a lake of no small pretensions, in which sea cow, *Hippopotamus*, were of common occurrence, but now it is merely a reedy swamp.

On the west side is the Berea ridge, from which there is a gradual rise westward through much broken country to the first plateau of the interior.

To the south are the extensive flats of Merebank and Wentworth, which are bounded on the west by the Table Mountain Sandstone hills of the Clermont estate, and on the east, by the sandhills of the Bluff peninsula, The general geology of the country between the first plateau of the interior and the Berea can be easily noted in the sections on the railway, which are practically continuous. In general geological features this section is similar to any section taken either to the north, in Victoria County or to the south, in the Umzinto District. This similarity is due to the fact that denudation, by river erosion, &c., along the coastal area has resulted in the disposition of the outcrops of the various formations in a direction practically parallel with the coast, and therefore in any traverse from the uplands to the coast the outcrops of the various formations are crossed at right angles and in the same order.

[illegible] E. [illegible] (see p. 114)

Near Inchanga, on the first plateau, which extends from Botha's Hill to Pietermaritzburg, from 2,000 to 3,000 feet above sea-level, the oldest rock formations on the east coast, granite and metamorphic rocks, are to be seen. At Botha's Hill they are succeeded, with the intervention of an unconformity, by a series of horizontally bedded sandstones which represent the Table Mountain Sandstones of the old Colony. These persist as far as Malvern, where they are overlaid again unconformably by the glacial Ecca Conglomerate.* Between this point and the Berea, the Table Mountain Sandstones are exposed at intervals through the Ecca Conglomerate. At the eastern base of the Berea this glacial deposit is again overlaid with a slight unconformity by the Ecca Shales, which at the Bluff are succeeded, also with an intervening unconformity, by a series of calcareous sandstones, which so far have not shown any palæontological evidences of their geological age, but they will, I think, probably prove to belong to the Cretaceous Series which are so well developed on the littoral of Zululand to the north, and at St. John's river to the south.

E

See p 114 line 4.

On the flats in the neighbourhood of Durban few outcrops of rock are to be met with owing to the great thickness of the Pleistocene and Recent sands and clays. On the northern side of the Umgeni river, from its mouth to the bridge, the glacial Ecca Conglomerate crops at the surface, and is extensively worked at the Corporation quarries for road metal, ballast, and material for harbour concrete work for use in the borough. Here there are some fine sections of this rock exposed, in vertical cliffs of some 150 feet in height. Advantage has been taken, in starting the quarries, of the erosion of the Umgeni river through the Ecca Conglomerate of the Berea, which has produced a precipitous outcrop of that rock on both sides of the river. A very large amount of material has been removed from these quarries.

The sections exposed in this district are of a most instructive and valuable kind, but their description and illustration I defer to a future occasion.

About a mile to the north of the crossing of the Isipingo road over the Umlazi river the glacial Ecca Conglomerate is exposed on the roadside. The ridge known as the Berea is composed of the same rock, which, however, does not often show at the surface, as the Berea is covered with a considerable deposit of Pleistocene and Recent sand. Immediately behind the Berea to the west, the Table Mountain Sandstones outcrop. This outcrop must have formed a ridge during the Ecca Glacial Period, and now divides the outcrop of the Ecca Conglomerate of the Berea from that at Malvern. On the railway near the latter place to the east, an interesting section of this glacial conglomerate is seen, where the exposure has been much extended owing to the excavations made in it for road metal, &c. A remarkable series of faulting occurs in this section, which I hope to describe at some later date.

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* First Report of the Geological Survey of Natal and Zululand. Plate XIV.

The only other outcrop of rock of which I am aware, on the flats, is near Congella, where black carbonaceous shales are present at the surface. Close to this spot there is an outcrop of intrusive basaltic rock which, in the early "fifties," was quarried, probably for road metal. On this outcrop of shale a bore was put down by Mr. Jonsson to a depth of over 300 feet. Mr. J. Goodricke has kindly furnished me with information relative to this bore, and also the others, in this neighbourhood, put down by him. The rocks passed through were dark carbonaceous shales, with occasional intrusive sills of basalt. An artesian mineral water was struck in the bore above referred to, and this water still overflows at the orifice of the bore. In all the other bores mentioned by Mr. Goodricke the rocks passed through were of a similar character, dark-coloured carbonaceous shales with occasional basaltic intrusions, which varied much in thickness and petrological character. Not far from the point at which Mr. Jonsson bored, an outcrop of basaltic rock occurs close to the railway. The presence of these intrusive basaltic rocks among the Lower Ecca dark shales is quite characteristic of the occurrence of the latter elsewhere, not only in Natal and the east coast, but also in Cape Colony.

Further to the south, at Clermont quarry, the Table Mountain Sandstones crop out, and they form the rising ground to the west and south. Some time ago a bore was put down, on the flat to the south-east of the quarry, to a depth of 150 feet. From the specimens of the core still left on the ground it was evident that the bore had passed through basaltic rock (not felsite, as recorded in the Mines Department Report for 1892) and sandstones, which are undoubtedly the Table Mountain Sandstones of the quarry. These sandstones are older than the glacial Ecca Conglomerate which rests unconformably upon them, and their presence is therefore significant in curtailing the area occupied by the younger coal-bearing Ecca Series. In the canal now being excavated near Wentworth railway station, large boulders of sandstone were met with among the sands and clays of the flat. Their large size and angular shape would point to their local origin, and it is extremely probable that the Table Mountain Sandstones exist close to the surface over this flat from the Clermont ridge to the south end of the Bluff peninsula.

If this be the case, which is exceedingly probable, the presence of the Table Mountain Sandstones over this part of the Merebank flat would necessarily curtail the extension southwards of the Lower Ecca Shales of the Durban Bay area.) To a certain extent this southern curtailment of the Ecca Shales, above which coal can only be expected to occur, is supported by the presence of the outcrop of the glacial Ecca Conglomerate a mile or so to the south before the crossing of the Umlazi river, where it rests unconformably on the Table Mountain Sandstones.

In the Clermont quarry, where the Table Mountain Sandstones have been quarried for a series of years as building stones and road metal, &c., some interesting geological features occur, which are worthy of closer attention than it has been possible as yet to give them.

In the outcrops of these rocks, [1)the glacial Ecca Conglomerate at Umgeni quarry, 2)the same rock forming the Berea, 3)the Table Mountain Sandstones at Clermont, and probably on the Wentworth flats,] we have, roughly, the limit landwards of the Ecca Shale Series, which overlies these formations with a slight dip seawards. This dip can be noted in the shales which are exposed at the bore at Congella, and shows that, in their projection eastwards, they pass under the alluvials of the Bay.

The Ecca Series, as it is exposed in the Umhlali district of the north coast and in the coal-fields of Zululand, have invariably the same succession—that is, a series of black shales, generally carbonaceous, resting usually with a slight unconformity on the glacial Ecca Conglomerate. These are succeeded upwards by a less thickness of light grey coloured shales, and they, in their turn, by the coal-bearing series of sandstones and shales with thin coals. There is no break in the succession of strata from the glacial Ecca Conglomerate up through the shales to the coal-bearing beds at the top of the Ecca Series, with the exception of the slight unconformity immediately above the glacial conglomerate. So far as I have seen, the succeeding series, the Beaufort Series, are quite conformable with the coal-bearing series of the Eccas.

In the Durban area we get the glacial conglomerate, the base of the Ecca Series, and in the Congella bore, overlying the conglomerate, over 300 feet of black carbonaceous shales, which are undoubtedly the representatives of the black shales immediately overlying the glacial Ecca Conglomerate in the areas mentioned above, at Umhlali and in Zululand. The succeeding portions of the Ecca Series, comprising the light grey shales and the coal-bearing series of sandstones and shales, are not anywhere exposed in the Durban area, if they exist at all, which is not probable, owing to the large quantities of Pleistocene and Recent alluvial and wind-blown sands which cover the surface to so great a depth.

The distribution of the Ecca Series along the coast of Natal is as follows: Between Port Shepstone and Isipingo, outcrops of the lower members of the series, the glacial conglomerate and overlying black shales, fringe the coast at intervals. In no case, however, are the exposures of shales of any great thickness.

Between Isipingo and the mouth of the Umgeni river we have the Durban basin which I have just described. Further to the north, is the edge of the basin which exists in the neighbourhood of Tongaat and Umhlali, and some miles to the north of the Tugela river mouth we get the basin of the Umlalazi coal-field in Zululand. This is the northern limit, on the coast, of the occurrence of the coal-bearing Ecca Series, for, as far north as there is any knowledge of the geology of the littoral, in Zululand, Tongaland, Portuguese Territory, and Sofala, the surface rocks are of later date, and comprise the calcareous series of the Cretaceous Period, and in some localities probably rocks of Tertiary age.

These isolated outliers of the Ecca Series, bounded inland by the outcrops of the basal glacial conglomerate and the other older formations, may be individual portions of isolated basins of Ecca strata, or they may represent the denuded, irregular edges of one large basin, the bulk of which is now under the ocean. The latter, however, is probably the case. The outcrop of the coal-bearing portion of the Ecca Series does not extend farther inland than four miles from the coast, except in the case of the Umlalazi coal-field in Zululand. It is more than likely that this coal basin, the remains of which are present at intervals along our coast, was distinct from that in which the coal measures of Dundee and Newcastle were laid down. They were separated from one another by the Palæozoic and Granitic rocks which now form a well-marked belt running from the Tugela river through Inchanga and Botha's Hill to the coast at St. John's river. The relative levels of these two coal-basins have subsequently been altered, owing chiefly to faulting, which occurs frequently between Inchanga and the coast, although the individual faults are never of large size. The gradual elevation of the country has also assisted in this alteration of level. There is now no doubt that they are both of Upper Ecca age, but whether they were deposited synchronously we are not yet in a position to state. Wherever remains of the fossil flora occur their general facies is the same, consisting of the characteristic genera *Glossopteris*, *Gangamopteris*, *Phyllotheca*, *&c.*

4 mls. (see p 113.)

= B. A. [illegible] physiography)

cf. Pirie's [illegible] about N&S.

With regard to the Bluff itself and the ridge which connects it with the mainland, few rock-outcrops occur except at the northern extremity. Here the rocky scarp which faces the ocean consists of a much eroded and weather-worn cliff of yellow calcareous sandstones, showing remarkably good examples of false bedding, which has been made very apparent by weathering. So far as I could discover, they are entirely unfossiliferous, and therefore there is no clue to their age. They are, however, certainly younger than the Ecca Series, upon which they undoubtedly rest unconformably. No rock exposures have yet been noted on the sand-covered connecting ridge; in fact, the first outcrop is this same rock which occurs on the beach at Wentworth. I believe it also occurs at Isipingo, while it is reported to be present to the west of Clermont quarry, where it rests upon the Table Mountain Sandstones. At the northern end of the Berea, above the Umgeni quarry, there are evidences, in the alluvial sands, of its previous presence locally. Probably much of the nodular calcareous material which occurs disseminated through the surface sands has been derived from the denudation of this local outlier of the calcareous Bluff rock.

In this locality, on the top of the Berea large quantities of Recent marine shells, chiefly mussels, small gasteropods and limpets, occur in the sands. It is quite evident from the large quantities of these shells and their wide distribution through the sands that they were not carried there by human agency, but point to a time when the top of the Berea was under the waters of the ocean. In fact, their presence is further evidence of the geologically recent elevation of the Natal coast-line.

On the seaward face of the Bluff, a few hundred yards south of the Cave Rock, remains of a raised-beach occur, more than 20 feet above the present high-water mark. Its presence here has no doubt been due to the calcareous nature of the sandstones forming the Bluff. The materials of which it consists have been cemented together by the calcareous matter derived from the Bluff sandstones. Very little of the old beach now remains, except small patches which have survived denudation by the protection afforded them, by their position, in the crevices and cavities of the decomposed face of the cliff. The contents of this raised beach are chiefly oysters and other mollusca, probably of the same species as those now living in the neighbouring seas, showing that this elevation of the land, as exemplified by the presence of the ancient raised beach so many feet above the present water-level, must have taken place within geologically recent times. The remnants of this beach have, however, another and very important significance in reference to the present subject, the occurrence of coal-bearing strata under the Bluff. The materials of which it consists are chiefly coarse sand, shells and a few well-rounded boulders. Mixed with these, however, and scattered through the mass occur numbers of small pebbles of black and grey shales, which could only have been derived from the rocks forming the bed of the ocean to the east. These are undoubtedly fragments of Ecca shales and their presence in this ancient shore deposit, facing the ocean, goes a considerable way to prove that some portion of the Ecca Series exists on the ocean floor to the east of the Bluff. The inference necessarily follows, that it is more than probable that the Ecca Series is continuous, from the shale outcrops of the Congella bore, underneath the alluvials of the bay and under the calcareous sandstones of the Bluff.

It has been suggested locally that there is a parallel between the geology of Durban Bay and that of Sydney Harbour, New South Wales, Australia. The physical geology of the two places is entirely different, even the origin of the harbour in each case being due to widely different causes. Sydney Harbour, as well as the others along the eastern coast of Australia, was formed by the slow subsidence of the land, which thus allowed what originally were land valleys to be converted into magnificent harbours, by the influx of the sea into them. Durban Harbour has been formed on a gradually rising coast-line, and originated through the protection afforded by the calcareous rocks of the Bluff, to the estuary formed by the denudation of the various rivers that flow into it.

From a geological point of view there is a certain analogy, but there are also some very wide differences, as can be seen by comparing the two sections on Plate VIII. At Sydney, the geological structure is a simple synclinal trough consisting of the Hawkesbury Sandstones (Triassic) overlying, with the intervention of the Narrabeen Shales, the coal-bearing Permo-Carboniferous Series, which outcrops at the edges of the trough, to the north, in the Newcastle District; to the south, in the Illawarra District; to the west, in the Lithgow District; while eastward they probably crop out on the bed of the ocean. For a number of years special attention was given, by the Geological Survey, to the geological examination of these outcrops, which are separated from one another by a hundred miles of country, over which the Hawkesbury Sandstones and overlying shales are the surface rocks. The various coal-seams in the southern outcrop were ultimately correlated with similar beds in the northern coal-field, chiefly by means of palæontological evidence, with the result that the beds forming the two outcrops were proved to be portions of the same series of strata. This, together with the stratigraphical evidence as to the geological structure, disposition and relations of the Hawkesbury Sandstones to the coal-bearing Series, led to the conclusion, that there was a great probability of the coal-bearing Series persisting in a trough-like form underneath the Hawkesbury Sandstones and Narrabeen Shales, so that the beds in the Newcastle District would be continuous with those which outcrop in the Illawarra District. The result of this was the sinking of a bore, in Sydney, which successfully struck coal at nearly 3,000 feet. By comparing the above description with my description of the geology of Durban Bay it will be seen how little resemblance there really is between the two.

There is little doubt of the presence of the Ecca Series below the calcareous sandstones of the Bluff, and it is possible that there may be thin coal-seams among them, just as there are on the coast at Umhlali, but the question as to the occurrence of payable coal is very problematical. If the series keeps the low dip to the east, which it has at the Congella bore, across the bay to the Bluff, a distance of about three miles, there is certainly not much room for the coming in of any thickness of beds higher in the series than those at the Congella bore, which is undoubtedly sunk in the black shales immediately overlying the glacial Ecca Conglomerate. A persistent dip of 3 degrees, without the intervention of faulting or other displacement of the strata, would allow of a little over 800 feet of beds being brought in from sea-level at the Bluff down to the horizon of the black shales at the top of the Congella bore. There is no evidence to show at what depth from the surface the unconformity between the Bluff calcareous sandstones and the Ecca Series occurs. The deeper this is, the less will the thickness of the Ecca beds be. If the dip alters and assumes a high angle, then there would be a probability of getting some at least of the Upper Ecca beds, which often carry coal, under the Bluff. The same might result by the intervention of faulting with a downthrow to the eastward; but judging from the other districts in which I have seen the coal-bearing Ecca Series, faulting to any extent is of rare occurrence. As I have previously stated, the prospects of obtaining payable coal under the Bluff are not of an encouraging nature.

GEOLOGICAL TRAVERSE

FROM

PIETERMARITZBURG *viâ* RICHMOND

TO THE

UMZINTO DISTRICT.

GEOLOGICAL TRAVERSE FROM PIETERMARITZBURG *viâ* RICHMOND TO THE UMZINTO DISTRICT.

The country in these districts exhibits a diversity of scenery and physical geology which is typical of the country in Natal between the second plateau and the sea-coast. This diversity has been entirely due to the effects of river and atmospheric denudation on a variety of rock structures. The various effects of erosion on granites, are to be seen in the enormous and rugged valleys to the west and north-west of Umzinto; while the results on the Table Mountain Sandstones are seen in the isolated flat-topped mountains of the same district. The undulating plateau of Ecca shales, (which stretches from Pietermaritzburg westward,) terminates beyond Richmond at the valley of the Umkomaas river, which has cut through the whole Ecca Series to the glacial Ecca Conglomerate which outcrops in its bed. The same plateau-like country of Ecca beds form the High Flats and Ixopo Districts. To the east of these, a narrow strip of mountainous country, consisting of flat-topped mountains formed of outliers of Table Mountain Sandstones, intervenes. As these sandstone outliers die out towards the coast the country becomes rugged, and is deeply carved out of the granites and metamorphic rocks of the Umzinto district. (cf. p. 111)

From Pietermaritzburg, through Fox Hills, by Thornville Junction and Nel's Rust, to Richmond, the rocks consist of the lower portion of the Ecca Series with numerous intrusions of basaltic rock. Some miles to the east of Thornville Junction, in the valley of the Imputshini river, the glacial Ecca Conglomerate is exposed. To the southward, in the valley of the Umlaas river, below Camperdown, it outcrops extensively. To the north and north-west it disappears under the Ecca Shales, a short distance beyond Manderston, and is not known to reappear again in the Colony to the north. To the north-west, however, it outcrops in the valley of the Umgeni river at Baynes' Drift and again in the Tugela river valley near Krantz Kop. Southward from the Umlaas river it forms a continuous outcrop as far as the northern bank of the Umquahumbie river near Cleveland Hill. The unconformity between it and the Table Mountain Sandstones is well seen in the road section at this spot. Forming the range which traverses the farms "Leeu Poort," "Mount Desire," and "Lovo Dale," to the west of this glacial conglomerate outcrop, from Manderston southward to the Umkomaas river valley, is an exposure of Table Mountain Sandstones, against which the conglomerate abuts. The area occupied by the sandstones is of large extent to the immediate south of Manderston, passing up the Umlaas river valley nearly to Nel's Rust, and from thence past the Richmond and Mid-Ilovo road into the Umkomaas valley. On the Ilovo river to the west of the farms "Pulteney" and "Sunnyside" it is again overlaid by the glacial Ecca Conglomerate, which here occupies the valley of the river in a more or less north and south belt of no great width. From the boundary of the Commonage where it is crossed by the Richmond and Mid-Ilovo road, the conglomerate is overlaid by the Ecca Shales, which persist northwards to Richmond, and south-eastward to the Umquabane river valley, in the lower part of which the glacial conglomerate is again exposed. This outcrop near the source of the Ilovo river is at a much higher level than that in the Umquabane and Umkomaas river-beds. In many places evidences can be seen of a distinct but slight unconformity between the conglomerate and the overlying shales.

In the neighbourhood of Richmond, as I have previously stated, the whole of the Ecca Series is represented from the glacial conglomerate of the Umkomaas valley up through the black and grey shales to the sandstone series, which in other parts of the Colony contains thin, impure coal-seams. Indeed, in one or two localities to the north of the town thin coal-seams of indifferent coal and carbonaceous shales are known to occur among these sandstones, which are much intruded by basaltic sills and dykes, the former being frequently of great extent and thickness. These have greatly aided, by their denudation, the production of the rich agricultural soils of the district; but their presence here among the coal-bearing sandstone series is much against the occurrence of unaltered coal of payable quality.

The highest rocks exposed in the vicinity of Richmond are, I think, without doubt, the upper or coal-bearing portion of the Ecca Series. They consist of coarse sandstones and shales, and they can quite distinctly be traced from this neighbourhood on the same horizon as the sandstones of the Town Hill at Pietermaritzburg. Unfortunately no fossils have yet been collected from these rocks, so that at present there is no palæontological evidence to support this correlation. Stratigraphically, however, it would seem to me, that, in the whole series of the Town Hill and at Richmond, we have to all appearance a succession of strata which closely resembles, both petrologically and in their relations to the glacial Ecca Conglomerate, the series of Ecca beds on the north coast at Umhlali. The only difference is in the upper portion of the series, where the sandstones are much more developed at the expense of the coals and shales in the Pietermaritzburg Town Hill and Richmond sections than they are in the Umhlali sections. Still, I think that there is little doubt that the inland series can be correlated with the coast series, although there are, not unnaturally, local differences in the character of the material forming the individual beds of the upper portion of the series.

North

Further to the [illegible] of Maritzburg, in the York and Greytown Districts, thin coal-seams occur among a series of sandstones overlying what are undoubtedly the Ecca Shales. In these districts we still have the same sequence of beds. At Baynes' Drift, at the Umgeni river, we have the glacial Ecca Conglomerate resting unconformably on the Table Mountain Sandstones of the Noodsberg, succeeded by the black and grey shales which are followed by the sandstone series containing thin coal-seams, in the neighbourhood of York and Greytown. Coal outcrops occur in this district which have been opened up, but have proved to consist of inferior coal of no value.

I do not know from personal observation the sequence of the beds in the Estcourt district, some 70 miles ~~north~~ of Pietermaritzburg N.W. and 1,600 feet higher up, but from what I have seen of the palæontology of the shales associated with the thin, impure coal-seams of that area I would have no hesitation in believing that they belong to the Ecca Series. Numerous examples of *Glossopteris Browniana*, Brongn., and *Phyllotheca*, have been obtained from among the shales of the coal-bearing series of Estcourt, in the neighbourhood of which thin impure coal-seams have been prospected but with no good result.

With regard to our northern coal-field in the Newcastle and Dundee Districts, there seems to me no doubt that the coal measures there, with their *Glossopteris* fossil flora, belong to the upper portion of the Ecca Series, and not, as was previously suggested by the earlier geologists, to the Stormberg portion of the Upper Karoo Series of Cape Colony. Among the shales accompanying the coal-seams in the Newcastle District, at the Ramsay Colliery, Wessels Nek, the Newcastle Syndicate Colliery Company's mine, near Newcastle, I have seen specimens of *Glossopteris* and *Phyllotheca* in abundance. Over the northern area of Natal, beyond the Tugela river, large developments of carbonaceous shales and frequently good bituminous coal-seams occur among the sandstone series; the latter forming the productive industry of the district. Towards the coast, to the south and east, however, they become of less frequent occurrence, their place being taken by arenaceous shales and sandstones. In the Estcourt District thin coals and carbonaceous shales with plant remains are present; but when we get to the Town Hill, Pietermaritzburg, and the Richmond District, little or no trace of coal exists, and even the carbonaceous shales are more or less replaced by sandstones in the upper or coal-bearing portion of the series. A similar condition of things exists in the York and Greytown Ecca Series, to that in the Estcourt district. In the New Territory the Ecca Series, with its *Glossopteris* flora, covers a considerable area. Locally coal-seams are known to occur, and some of them have been opened up for local consumption. In Zululand we have again other areas, more or less continuous geologically, formed of the Ecca Series; and over these areas, which embrace the Umlalaas, Ntambanana, and St. Lucia coal-fields, seams of semi-anthracitic coal, with plant-bearing shales often of workable thickness, are of common occurrence. The presence of the Ecca Series in the Vryheid District forms a connection between the coal-bearing series of Newcastle and Dundee, and the coal-bearing Ecca Series of Northern Zululand. In the Umhlali District of Victoria County, we have very fossiliferous shales associated with a thin, impure coal-seam of Ecca age. (See p. 97.)

It would thus seem as if, during the deposition of the upper portion of the Ecca Series, there existed two main basins in which the plants, whose remains were requisite for the formation of the coal-seams, flourished in sufficient quantity to supply the material to form coal-seams of any thickness in these basins. One of these now forms the Dundee and Newcastle coal-field, while the other occupies the east central portion of Zululand. It is just possible there may have been a third, which would now be under the ocean, and whose western edge is now represented by the patches of the Ecca Shales which form outliers along the coast of Natal; but I think the probability is that these north-coast outliers have formed a portion of the Zululand basin.

The remaining areas occupied by the Upper Ecca Series, the Estcourt, Maritzburg, Richmond, York and Greytown, portions of the New Territory, North Coast District, represent localities in which the sediment was chiefly of a sandy description, although occasionally in all these districts there are local but circumscribed areas where the deposition of carbonaceous material has gone on. to a certain extent. This is instanced by the presence of occasional occurrences of thin, poor coal-seams and fossiliferous carbonaceous shales.

In the Upper Ecca Series the alternations of sediment, as represented by the various beds, was remarkably frequent and irregular. It is a common thing to see, in a single section even of no great extent, not only alternations vertically, of shales, sandstones, and coal-seams, but horizontally as well. It is therefore safe to say of the Upper Ecca Series of the above-mentioned districts that although the individual coal-outcrops which have been prospected have turned out to be of too inferior a quality for commercial purposes, it does not necessarily follow that locally deposits of passable coal may not occur among these beds. At the same time it is extremely probable that if they exist they will, when found, prove to cover a very circumscribed area. With particular reference to the neighbourhood of Richmond and the Town Hill of Pietermaritzburg, the upper portion of the series contains little else than thick bedded sandstones, much cut up by intrusive basaltic rocks; there is, I think, little likelihood that in the vicinity of either place, will coal of good quality be found.

From Richmond to some distance past Nicholson's Farm on the drop into the valley of the Umkomaas, the Lower Ecca Shales persist with occasional basaltic intrusions. Some distance down the slope the underlying Ecca Conglomerate appears. This rock occupies not only the valley of the Umquabane and Umkomaas rivers, but also forms the ridge between the junction of these two rivers. Its thickness here must be very considerable, for this ridge is at least a thousand feet in height. On crossing this outcrop of glacial conglomerate in the Umkomaas valley, some distance up the main road to the plateau of Waterfall, the Ecca Shales again appear and form this plateau for a long distance towards Ixopo. Some miles down the Umkomaas river, below the crossing, the deeper degradation of the valley has exposed the Table Mountain Sandstones below the glacial Ecca Conglomerate, in the district of the Inhlazuka Mountain. Still further down the valley the Table Mountain Sandstones give place to the Granitic and Metamorphic Series, which persist from above the junction of the Ilovo river nearly to the sea coast.

In passing down from the Waterfall plateau into the Ixopo river valley, on the road to High Flats, the Ecca Conglomerate again outcrops from under the Ecca Shales near the river on the west side of the valley. This outcrop persists all the way up the eastern slope and on to High Flats, where it can be noticed nearly as far as Mr. Walker's farm, a very considerable height above the level of either the bed of the Umkomaas or Ixopo river.

It is interesting to note in this district, as in other parts of the Colony, the difference of level at which, within a few miles, the glacial conglomerate often occurs. This is not due to the general dip of the sedimentary formations, for the underlying Table Mountain Sandstones are practically horizontal and the overlying Ecca Shales are the same; therefore the intervening glacial conglomerate is lying in the true position in which it was deposited. There are also no evidences of subsequent fracture or faulting, but within a distance of a few miles the glacial conglomerate is present on High Flats and also in the bed of the Umkomaas river, a difference of level of at least 1,500 feet. A similar condition of things exists between the junction of the Umquabane and Umkomaas rivers, where the glacial conglomerate outcrops from the beds of both rivers up to the top of the intervening ridge, nearly 1,000 feet high, enclosed by these streams. It would seem that, in this instance, the glacial deposit was at least that thickness. I do not know of any other locality where it attains so great a thickness, either in Natal or Zululand, and it is probable that this is due to a local cause. This occurrence lends a slight support to the idea that the glacial Ecca Conglomerate of Natal and Zululand is of terrestrial origin and is of the nature of morainic material which is the residue of the glacial detritus, left on the irregularities of the land surface after the melting and retreat of the ice-sheet which covered it. In the locality mentioned above we have, therefore, the glacial *débris* still resting upon the irregular slopes of the old land surface upon which it was left by the melting of the ice-sheet, which would satisfactorily explain the great difference of level at which this deposit occurs. It is quite probable that under many portions of the conglomerate striated pavements, produced by the slow passage of the ice-sheet, with its enclosed boulders and *débris*, over the surface of the underlying rocks, are present on the rocks below. I have no doubt that, at the edges of the outcrops of the glacial conglomerate, where the latter has only lately been removed by denudation, some fine examples of these glacially striated pavements will be found, just as they occur further to the north under the glacial conglomerate in Victoria County.

Close to Mr. Walker's farm the Table Mountain Sandstones are again exposed. This exposure is a prolongation of the outcrop mentioned as occurring on the north side of the Umkomaas valley, passing south-eastwards by Inhlongozi Mountain and on to St. John's river mouth, where it disappears into the ocean. They are usually quite horizontal and of a reddish or pink colour, and are seen here, as in other parts of the Colony, to flank the outcrops of the Granitic and Metamorphic Series. They form either isolated table-topped mountains or extensive plateaux bounded by precipitous escarpments of the same rock, with usually a boulder-strewn talus which descends into the granitic valley below, for in no instance is this series of any great thickness in this district, and it always consists of the lower beds of the formation, which are usually felspathic conglomerates.

Near the top of the mountain to the east of Mr. Walker's farm the granites begin to outcrop; in fact, the summit of the mountain some miles to the east consists of an outlier of the Table Mountain Sandstones, while the lower portion is of granite, which persists right from this point to the coast at Umzinto. It is in this rock that the auriferous reefs were worked some years ago at Dumisa, and between that place and Umzinto. This granite of the Hlutenkunga Mountain is largely porphyritic, is hornblendic, and contains pink felspar. It has undergone a good deal of shearing. Associated with the granites are a series of gneisses and schists which are chiefly hornblendic, and it is among these that the reefs which have been worked for gold occur at the Dumisa and Holman's Mine, &c. Many other varieties of schist and gneiss are present in the district. In the immediate vicinity of the Dumisa Mine the metamorphic rocks are overlaid by the Table Mountain Sandstones, which are again, to the east, overlaid by an outlier of Ecca Conglomerate, which, however, is of no great extent. This is the eastern limit of the sedimentary rocks and the glacial conglomerate until within a very short distance of the coast-line, where we again get the Table Mountain Sandstones overlaid by the Ecca Conglomerate at Park Rynie and other places on the immediate shore-line.

The granites of the Umzinto District consist of two kinds; a grey porphyritic granite which occurs in the country to the west of Umzinto, and a red granite which occurs near the sea coast. The latter has lately been used for ornamental building purposes in Durban. It makes a very good rough-hewn building stone, and takes a good polish. It, however, needs to be picked, as a very common feature of the rock is that it contains great numbers of large segregations of mica and hornblende, which do not look well in a polished surface.

More than a decade ago, in the district between Dumisa and Umzinto, a considerable amount of prospecting for gold was undertaken. The chief amount of work was done by tunnelling, to which the precipitous nature of the country lent itself admirably. In most of the mines opened up the auriferous ore consisted of a siliceous matrix, containing pyrites, and often near the surface free gold, which had no doubt been derived from the pyrites by superficial oxidation. In some cases in which tunnels were run into the hillsides there was little or no trace of the presence of a quartz reef or lode, as the gold-yielding material consisted wholly of the crushed gneiss or schist, as the case might be, with pyrites, formed along a joint or fault in the metamorphic rocks. The thickness of the quartz reefs and the auriferous crushed joint-rock varied considerably, from ½ inch to 2 or 3 feet, while they are most irregular in their gold-bearing capacity. This irregularity in the thickness of the veins was so conclusively proved, both in the tunnels and shafts, some of the latter going to nearly 200 feet in depth on the vein, that this evidence, taken in conjunction with the fact that in the area mentioned the superficial geological evidence shows that among these granitic and metamorphic rocks there has been remarkably little extensive fracturing, and therefore the presence of reefs or lodes of any permanency or extent is very problematical.

A few figures as to yield of gold may not be out of place here to show how irregular its occurrences have proved in the various reefs. In 1892 crushings were made at a local battery from various mines in the vicinity with the following results:—

Dumisa Mine, 25 tons yielded 16 oz. 14 dwts. Pyrites not treated.
Mimosa Mine, 20 tons yielded 3 oz. 10 dwts.
Mimosa Mine, 8 tons (50 feet level) yielded 2 oz. 9 dwts.
Golden Valley Estate, 7½ tons (60 feet level) yielded 3 oz. 1 dwt.
6 tons blanketings from old Dumisa crushings of 1889 gave 3 oz. 5 dwts.

It will thus be seen that the irregularity of the thickness and want of persistence of the veins, together with the inequality of gold yield, is decidedly against the probability of the development of a gold industry in this district, and the country now under mining reserve would be much more valuable as agricultural or grazing lands, especially as almost all the large native locations in the district are more or less on the granitic and metamorphic formations, and, therefore, to a very large extent, contain practically equal prospects for mining developments.

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THE GEOLOGY OF THE MELMOTH DISTRICT, ZULULAND.

The area of country embraced by this map consists principally of that portion of Zululand formerly known as Proviso B, with a small piece of the neighbouring Nkandhla District. It occupies the high country immediately to the east and south of the watershed at Entonjaneni which separates the waters flowing into the Umfolosi from those which flow into the Umhlatuzi rivers. Much of the northern part is plateau-like from the presence of horizontally bedded sandstones; while in the south, where the principal formations are granitic and metamorphic rocks, the country is of the most rugged description. The general trend of the river valleys is easterly and south-easterly, and most of the streams are perennial in their flow. In fact, it is one of the best-watered districts in the country. Native timber is scarce except in small patches in the kloofs, although there are considerable numbers of isolated wattle plantations scattered over the district, chiefly on the higher hilltops and ridges. It includes the country surrounding the town of Melmoth, is exceedingly fertile, and during the cold season of the year is largely used for the winter pasturing of stock.

The geological formations represented in this area are as follows: Granite, Metamorphic Series (probably Hospital Hill Series), Table Mountain Sandstones, glacial Ecca Conglomerate, and over a small area, in the Umhlatuzi valley, an outcrop of Lower Ecca Shales. Intrusive basaltic rocks are infrequent, and usually outcrop over very small areas.

The succession of these formations is the same as in Natal. The Table Mountain Sandstones rest unconformably on the Granitic and Metamorphic Series; while the Ecca Conglomerate also rests unconformably on the Table Mountain Sandstones.

In distribution, the Granitic and Metamorphic Series occupy the lower portions of the valleys, while the higher hills and ridges are capped with Table Mountain Sandstones, which locally have small patches of glacial Ecca Conglomerate overlying it.

Towards the crossing of the northern road over the White Umfolosi river a series of chocolate-coloured shales occur. On the Zululand side of the boundary they do not occupy a very large area, but in the Vryheid District, in the neighbourhood of the Denny Dalton mine, they have a considerable development, and have been identified there as a portion of the Hospital Hill Series of Johannesburg by Dr. Molengraaff in his report on that district in 1898.

The Ecca Conglomerate occurs covering a limited area in the neighbourhood of Melmoth as far north as the Imfule river. Another small outcrop occurs at Kataza north of the Melmoth and Nkandhla road, near " Mount Prospect." In the valley of the Umhlatuzi river, in the neighbourhood of Alison's old store, at the upper crossing between Melmoth and Eshowe, glacial Ecca Conglomerate also occurs, overlaid lower down the valley by the Ecca Shales. It is also present on the higher hills north of the Umfolosi river toward Ulundi Plain. The differences of level at which these various outcrops of Ecca Conglomerate occur in this district are very striking, the Umhlatuzi Valley outcrop being 1,000 feet below that at Melmoth. The same applies between the outcrops on Ulundi Plain and those on the Uvula Range to the south. In all cases it is distinctly unconformable with the underlying rock, whatever it may be. In most cases it rests upon the Table Mountain Sandstones. In the positions indicated above, it is undoubtedly of morainic origin, but to the west of Ulundi the glacial conglomerate shows intercalated sandstone beds, containing a few isolated pebbles and boulders.

The Table Mountain Sandstones occur to the east, west, and north of Melmoth; while to the south of the Umhlatuzi river they again come in. This latter outcrop is continuous with that which surrounds Eshowe. Between Eshowe and the Umhlatuzi drift it is, however, largely covered with glacial Ecca Conglomerate. As evidenced by the large numbers of outliers of this deposit which cap the granitic hills in the south-west, the Table Mountain Sandstones must have entirely covered this area. The valleys of the main rivers, the Umfolosi and Umhlatuzi, have been by denudation carved completely through this formation, and now the waters of these rivers are eroding the Metamorphic Series below. In both cases the valleys form extensive gorges, with smooth lower slopes of granite and schists, which are capped by precipices of sandstone many hundred feet in height. The result of this denudation has been that these sandstones form extensive plateaux which are much cut by the erosion of the local streams. One such plateau occurs to the north of Melmoth, on which the Suja and Esipikeni Trig. Beacons are. To the east of Melmoth, for a very long distance, this formation caps the ranges, giving them the usual flat-topped appearance. They are, however, ultimately replaced by the coal-bearing Ecca Sandstones of the Imtambanana coal-field.

As a rule the outcrops of this formation consist of the basement beds which rest upon the metamorphic rocks. They are, therefore, generally coarse-grained grits or conglomerates, and contain large quantities of kaolinised felspar. To the east of Melmoth, however, the sandstones are developed to a greater extent than to the west or north, and consequently the series is of much greater thickness, the lowermost beds of the series being under those forming the creek beds, while the highest beds are exposed on the mountain tops over a thousand feet above. They are generally of a red colour, and contain few or no shale beds interstratified with them. To the north-east of Melmoth some large quartz reefs occur cutting these sandstones. These reefs are prominent features in the landscape, but so far they have not shown any traces of gold or other mineral of any value.

The oldest formation of all is the Metamorphic Series, which consists of gneisses and schists, highly metamorphosed by the intrusion of the granite. The occurrence of granite among the schists and gneisses over this area is peculiar. It is present in isolated patches, sometimes of considerable extent, which outcrop from among the metamorphic rocks. Wherever I have been able to examine these in section there has been the usual gradation from a granite through gneiss to schist, just as there is in the larger typical section on the Engoye Mountains. In the neighbourhood of the crossing of the Umhlatuzi river, of the Melmoth and Nkandhla road, other metamorphic rocks occur besides gneisses and schists, namely, quartzites, jasperoid rocks, and altered conglomerate (banket). About half a mile below the crossing the junction between these metamorphic rocks and the Melmoth granites of the upper Umhlatuzi valley can be seen; and it is apparent that here at least these sedimentary rocks have been intruded by the granite.

The major portion of the granite over this area is of a grey colour, rarely porphyritic, but usually of a moderately uniform texture, having the crystals of felspar, quartz, and mica never developed to any great size. There are, however, local variations not only in the colour but in the constitution and composition of the rock. On the top of the ridge Madegela, to the east of Nkandhla, it is of a brick-red colour, the quartz grains being small but porphyritic, while the felspar and minute micas form a sort of base for the quartz crystals. Other varieties are also locally common.

Granite v.
Metamorphic

Previously, in my First Report, I have included the granites, gneisses and schists, &c., under the general term Metamorphic Series; but now with the more extended knowledge which I have since obtained of these rocks, I have little hesitation in separating the granites from the others, which should alone be included among the Metamorphic Series. It may probably be found necessary in the future to make a distinction between the gneisses and schists and the less highly altered series of slates, quartzites, &c., which occur in the Nkandhla District. The section to which I have alluded above, on the Upper Umhlatuzi river, is quite a typical one, showing that the granite has been intrusive among these originally sedimentary rocks, and was probably the cause of their metamorphism. In the case of the gneisses and schists there is no doubt of this. It is equally probable, I think, that the granites of the other areas, the Engoye Mountains, east of Eshowe, the belt of grey porphyritic granite, passing north-east and south-west through Inchanga, in Natal, will also prove to have been intrusive among a series of sedimentary rocks together with the granites of the Vryheid District and Swazieland. The remains of the gneisses and schists are rarely now developed to any great extent in any of these east coast localities, because the enormous denudation to which they were subjected, prior to the deposition of the Table

Mountain Sandstones, and represented by the unconformity between these two formations, has only left a few isolated outcrops of the more highly altered gneisses and schists which had been in close contact with the intruded granite.

In the Melmoth District the Granite and Metamorphic Series have an almost universal distribution, although in certain areas it is locally covered by outliers of Table Mountain Sandstones. In all the deeper valleys they are the prevailing rocks, and they are rarely intruded by basaltic sills or dykes. Natural sections of these rocks are not of frequent occurrence, because their outcrops are usually covered with a considerable thickness of decomposed material. Where they are to be seen the cleavage is always more or less vertical. As a rule the quartz reefs and lodes which have been worked for metals have been developed along the cleavage lines and rarely in fractures across them. In fact, there are slight evidences indeed of fracturing of any extent, and it is no doubt due to this that the lodes which have been followed containing gold have not been of a permanent character, only occurring as lenticular masses of limited extent along the cleavage lines which have been opened by crushing.

With regard to the less altered series of slates, quartzites, and conglomerates, which occur in two localities in the Melmoth area, they are important from the fact that a good deal of prospecting has been done among them. They are developed over a small area in the district of Ulundi, where the White Umfolosi river enters Zululand, and consist of very highly coloured ferruginous thin-bedded shales, exposed in the creek bed immediately to the south of the main road crossing the White Umfolosi river. They are probably an extension eastwards of the series which occurs some miles up the White Umfolosi river, at the crossing to the north-east of the Denny Dalton mine, where they are much better developed and exposed. Here they have been identified by Dr. Molengraaff as a portion of the Hospital Hill Series, which, in the neighbourhood of Johannesburg, represents the series of rocks immediately below those in which the auriferous conglomerates, or banket, of the Rand occurs. Here they have been cut through by the river, and extensive cliff sections of them are laid bare. Just below the crossing, and at the Denny Dalton mine, siliceous quartzites and auriferous conglomerates occur of considerable thickness, and are to all appearance associated with the chocolate-coloured slates of the Hospital Hill Series exposed in the river higher up. To the westward a considerable area is occupied by this series of quartzites and slates.

Outside the work that has been done on the Denny Dalton mine, a good deal of desultory prospecting has taken place both in the red shale beds and in the quartzites which are exposed along the course of the river. No discoveries of any consequence have yet resulted, although in a few cases traces of gold have been said to have been obtained in some of the quartzites. So far as I know no gold has ever been got in the washing of the river alluvials in the locality where these rocks occur. This is not, however, against the presence of gold in the rocks of the neighbourhood, as there have been few gold-fields in South Africa where the alluvials have shown the presence of gold in any quantity.

On an isolated hill close to the Umhlatuzi river in the Nkandhla District, and also on the hills on the other side of the river, a true banket (that is, a metamorphosed conglomerate or agglomerate carrying auriferous pyrites and often free gold) has been prospected by tunnel, &c. This banket occurs among a series of highly metamorphosed rocks, which occur in this neighbourhood overlying the Melmoth granites. Long prior to the deposition of the Table Mountain Sandstones these latter had intruded a series of sedimentary rocks of very much greater age than the Table Mountain Sandstones. This granitic intrusion was probably the initial cause of the metamorphism of these rocks into gneisses, talcose and chloritic schists, jasperoid rocks, quartzites, and much-altered conglomerates (bankets). They are much contorted, and fine sections showing the remarkable folding of these strata are to be seen in the vicinity of the crossing of the Melmoth and Nkandhla road through the Umhlatuzi river valley. A small belt of these much contorted rocks is still left in this neighbourhood. It extends over a limited area on the east side of the river on the farms "Diepkloof" and "Nineve." On the other side of the river towards Nkandhla it extends to near Cooper's store, where it is overlaid by an intrusion of basalt, and further on by the Ecca Conglomerate. It, however, passes a considerable distance up the valley of the Umhlatuzi river. On the left side of the river it is covered by the Table Mountain Sandstones on the farms "Naawport" and "Driefontein," while further up the river valley it is concealed by the Ecca Conglomerate. Lower down the valley, where the short cut from Melmoth to Nkandhla crosses the river, its place is taken by the granite which from this point outcrops in the river valley for many miles south-eastward. From this crossing it outcrops up the valley of the creek immediately to the south of Cooper's store for some distance. A small outcrop also exists near the eastern corner and boundary of "Prospect."

The exposures of these metamorphic rocks in this locality occupy a very circumscribed area, but, in comparison with other areas of metamorphic and granitic rocks, this shows much more evidences of prospecting than any other. Everywhere these rocks contain large quantities of quartz veins, most of them, however, very thin and of no great extent. They usually occupy the cleavage planes of the schists, although among the quartzites, conglomerates, and jasperoid rocks the old sedimentary divisions between them are yet apparent, and often the reefs occupy these divisions, which, when not contorted, have a direction W. 30 N. and E. 30 S., generally vertical. Sometimes these reefs are quartzitic and brecciated, and contain iron pyrites.

Fair prospects of gold were obtained at the outcrops of the banket beds, and this led to a considerable amount of work being done following these auriferous beds. Ultimately work has been altogether stopped, and it would seem to me that over this area, like many others, the quartz leaders and reefs are not of sufficient persistency and thickness to be payable, while the occurrence of gold in the banket is so irregular both as regards position and quantity that it is extremely doubtful if it will ever pay any one to proceed further with the development.

On the farm "Nineve," as early as 1894, a number of claims had been taken up for the prospecting for gold in what was styled banket. This so-called banket is of two kinds. On the eastern portion of the farm it consists of the unaltered basement conglomerates of the Table Mountain Sandstone Series, which on this farm thin out some distance to the east of the Umhlatuzi river. A good deal of trenching has been done on these conglomerates, both on this and the neighbouring farm "Prospect," but evidently with no success. This result would almost be expected, for although here these conglomerates have been originally formed of the *débris* resulting from the denudation of the older metamorphic rocks and the granites of the neighbourhood, the gold derived from these older rocks would necessarily be so irregularly disseminated in the conglomerate that its extraction would be too expensive for obtaining payable returns.

Such conglomerates containing gold are not of uncommon occurrence in many parts of the world, and may belong to almost any geological formation. The necessary conditions of their occurrence are that they be basement beds of a formation or the peripheral portion of beds which are separated by an unconformity from some more ancient series of rocks which are gold-bearing and whose degradation has furnished the material of which the newer conglomerates consist. One example may be given (although there are many). In the Mudgee District of New South Wales, Australia, a basement Carboniferous conglomerate has been worked for gold, though not very successfully. The material of which this conglomerate was formed was derived from the gold-bearing Silurian rocks below, between which and the conglomerate a well-marked unconformity exists. A local example has lately occurred at Umhlali, on the north-east coast of Natal, where it is reported that gold has been discovered in the conglomerates, which occur in that district. They are undoubtedly the basement beds of the Table Mountain Sandstones, which here rest on the Metamorphic Series, which are well exposed some miles to the west, in the Glendale valley. On the old road coming out of the valley these same basement felspathic conglomerates can be seen resting unconformably on the metamorphic rocks. A keen interest is being taken in this discovery, but from the nature of the rock, the method of its formation, and the original source from which the gold was derived, it will prove to be of an exceedingly patchy nature, and is not likely to be of a payable character.

On the same farm, "Nineve," nearer the river, a true banket occurs among the metamorphic rocks. Here the beds of jasperoid slates, conglomerates, and quartzites are very nearly vertical, and a good deal of tunnelling has been done in the prospecting of these various beds.

The banket consists of a siliceous matrix containing well-rounded pebbles of white and other coloured quartzes with iron pyrites locally distributed through the matrix.

On many of the farms over the western portion of Proviso B., where the granite and metamorphic rocks are exposed, prospecting for gold has been carried on for the last decade. Little, however, is now being done, as almost all the properties have been abandoned. Some casual work is at present being carried out on the farm "Nineve"; while Messrs. Symmonds, of Melmoth, are still working on a tributary of the Imfule river, about two miles to the south of the Suja Trig. Beacon. Some distance to the east of Melmoth, also in the valley of the Imfule river, prospecting for mica is carried on, but so far the specimens have been of no great size and of quite inferior quality.

Traces of copper, in the form of carbonates Malachite and Azurite, have been found in different portions of the Umhlatuzi river valley, chiefly in the granitic areas. No definite lodes have yet been discovered.

REPORT
ON THE
STORMBERG COAL-MEASURES,
TO THE
WEST OF MOLTENO,
CAPE COLONY.

REPORT ON THE STORMBERG COAL-MEASURES, TO THE WEST OF MOLTENO, CAPE COLONY.

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I need not here enter at length into the general geology of the district, as that has already been done, years ago, in the seventies, by Mr. E. J. Dunn, then Government Geologist of the Colony, and by Professor Green and others. Suffice it to say that the formations represented over this area are from below upwards: the *Beaufort Series*, which are exposed in the neighbourhood of Sterkstroom and elsewhere; the *Stormberg Series* containing the coal-seams; the *Red Beds;* the *Cave Sandstones*, and numerous igneous intrusions, with basaltic lavas capping the whole series.

The portion of this formation with which we have most to deal is the Stormberg Series, which have alone proved to contain payable coal. The limits of their outcrop are admirably shown on the geological map prepared for the Cape Government by Mr. E. J. Dunn nearly thirty years ago.

The Stormberg Series have originally extended over the whole area under examination, but at the present time many parts of the area have only the lower portions of the series represented, the upper beds having been removed by denudation. This is an important point to bear in mind in investigating the occurrence and presence of the coal-bearing horizon in any particular area. The beds are usually more or less horizontal, and denudation, by removing portions of these beds, has formed the valleys on whose sides the coal is exposed. Locally they are sometimes slightly tilted, but in all cases this has probably been entirely due to the local intrusions of igneous rocks, whose presence and distribution are also a most important point bearing on the same issue, as the results of their intrusion is often to alter the relative levels of the same beds locally. The areas occupied superficially by igneous rocks are shown roughly on Pl. IX. accompanying this report. Although this map only shows these rocks as they outcrop at the surface, the strata among which they occur are certain to be more or less affected at a depth by connecting intrusions of basaltic rocks.

In this district the coal-bearing horizon occurs towards the upper part of the Stormberg Series, and there is little doubt in my mind that the geological horizon of the shales among which the coal is worked in all the mines, from Contat's Mine by the Cape Collieries and " Roman Fontein " to Cyphergat and Molteno, is the same. The difference in the topographical level of the coal worked at the two last-mentioned places can quite easily, and I think truly, be explained by the presence of the various masses of intrusive igneous rocks which occur on the farms "Parde Kraal," the Molteno Commonage, and the south-eastern part of "Spree Kloof." This horizon can usually be readily traced by the presence of a peculiar ferruginous conglomerate which overlies the coal-bearing shales. A similar conglomerate is present some 40 feet or so above the Indwe coal. Thin, dirty coals and evidences of carbonaceous deposits occur on other horizons among this series, but none of them have yet proved of a payable nature. Over a considerable area of the south-west portion of "Groot Dam" and the adjoining part of Meyburgh's farm, and on "Hassies Fontein," such carbonaceous deposits of extremely irregular character occur immediately below the sandstone on which the shales containing the coal worked at "Roman Fontein" rest. With reference to this lower coal horizon, I would state that wherever the outcrops are visible the exposed carbonaceous deposits are of such poor quality and of so irregular a character that I think it is extremely doubtful that payable coal occurs on this horizon anywhere in this district.

The two principal factors which have produced local areas in which the coal horizon does not occur of a payable nature are denudation, which has eroded the strata down below the coal horizon, and the presence of intrusive igneous rocks, which have, in passing upwards, burnt and destroyed the coal in their immediate neighbourhood. Besides these there is the fact that over some areas where we have the coal horizon no coal exists. This is due to the fact that during the deposition of the Stormberg Series the coal was only deposited over local areas, and not in one continuous layer, and therefore its place in some areas is taken by sandstones or shales, according to the kind of material which was brought into the lakes in which these beds were formed. An example of this is seen on the farms "Groot Dam" and "Hassies Fontein," where the coal has thinned out to the westward, its place being taken by the increasing thickness of the overlying conglomerate. In the south-east portion of "Leuwen Kuil" the sandstones are largely developed at the expense of the carbonaceous shales in the neighbourhood of the coal horizon.

The igneous intrusive rocks which occur among the Stormberg Series are of two kinds—a porphyritic and a fine grained basalt. They occur as dykes and sills. The former usually pass more or less vertically through the strata, and are of all degrees of thickness from thin reticulations to 40 feet, as occurs in the Indwe Mine. They are often persistent over large areas of the country. One of these can be traced from the farm "Modder Fontein" through "Sea Cow Gat," "Hassies Fontein," "Roman Fontein," into "Modder Bult." At the Cape Collieries the presence of this dyke has prevented the working of the coal for a considerable distance owing to its destructive effect thereon, but there is no doubt that after passing through the dyke and a certain distance beyond, the coal would be found to be equal to that on the other side of the dyke, where it was unaffected by the intrusion.

The sills are of common occurrence, and have usually been intruded horizontally. Some of them are very extensive, and often have been squeezed in among the shales where the coal-seams occur. Wherever these sills are present they are connected below with dykes, which have been the vehicles by which they have arrived at the position in which they now are. They are therefore indications that in their neighbourhood the coal (if present) will be of poor quality.

On the farm "Modder Fontein" the upper portion of the mountain to the north of the new railway line to Deep Kloof mine consists entirely of basaltic rock, which outcrops down to the bottom of the valley to the north. Although these intrusive sills forming the summit of the mountain have, as shown by the section on the south face, intruded beds a little higher in the series than the coal horizon, there can be no doubt that the major portion of the mountain some distance from the southern outcrop of the coal will be found to consist of basaltic rock, which, forcing its way upwards through the strata, has destroyed the coal and altered and tilted the other sedimentary rocks.

The effects of such intrusive rocks are also well seen over the middle portion of "Roman Fontein," immediately south and east of Woolf's house.

In the valley of the Stormberg River, above Molteno, as far as its source, igneous rocks are of common occurrence. They are, however, mostly intruded among the rocks which are on a lower horizon than the coal horizon, while on the range which forms the boundary line between "Leuwen Kuil" and "Roman Fontein," the sills occur, intruding beds which are higher in geological position than the coal horizon. In this area the sills will be connected below with dykes, which must have passed through and affected the coal, if present.

With reference to "Roman Fontein" a good deal of prospecting has been done on Woolf's, Meyburgh's, and Le Grange's land. The oldest workings are on Woolf's property. The southern outcrop has been opened for short distances to the north of the house. The major portion of the hill on which the house stands consists of intrusive basaltic rock, which crops out as far as Meyburgh's farmhouse, so that the amount of coal to be won from this portion of the southern outcrop would be limited and inferior. Further down the creek, the outcrop disappears entirely underground, owing to a slight dip of the beds to the northward. Between this point and the boundary of "Leeuwen Kuil," the coal would probably have to be worked by shaft. It has been reported to have been struck in bores over portions of this area at depths considerably under 100 feet. The superficial covering of the coal would therefore be comparatively thin, and there is a possibility that it thereby might be affected by percolating surface waters. To the south-east, there is a considerable area of igneous rocks occurring close to the coal horizon. Their presence would materially circumscribe this coal-bearing area.

The northern outcrop on the opposite side of the valley from

wish to carry further the prospecting of this portion of Meyburgh's farm, I would suggest that the proper position for bore holes would be on the high ground to the north of the first bore put down some time ago.

As shown on Plate IX., the coal outcrop practically surrounds the farm "Leeuwen Kuil," except at its south-eastern end, where the creek which traverses the farm has eroded a narrow valley to a depth below the level of the coal horizon. By far the larger portion of this farm contains the coal horizon at no great depth. In the sides of the creek near the house a few small adits have been driven on this horizon exposing inferior surface-coal, but no prospecting has been attempted. This farm is wonderfully free from intrusive rocks, except on its southern boundary. Just over its western boundary the Cape Collieries work their seam on the same geological horizon, and further to the north the Deep Kloof mine shows the same coal. In both these mines coal of fairly good quality has been found. At the eastern outcrop on the same horizon, near the house on "Leeuwen Kuil," the coal does not appear to be so good, but it is much decomposed surface-coal, as none of the cuttings have gone any distance in, and therefore the exposure is merely superficial.

In arriving at an idea as to the probable area from which payable coal may be expected to be obtained, those portions occupied by igneous rocks and those which have undergone denudation to a lower level than the coal-bearing horizon have to be eliminated. This igneous area is shown on Plate IX. The remaining area shown on the same plate exhibits that portion of the district under which the coal horizon is present. As seen from an examination of the outcrops, coal of a payable quality does not exist uniformly along that outcrop. In some places it is good, in others it is much inferior, while often the shales contain no bituminous layers. Variations in the quality, thickness, and arrangement of the several bituminous layers making up the coal-seam occur in almost every mine that has been opened. Under these circumstances it is at present impossible to attempt to gauge with any degree of accuracy the probable amount of coal which may be expected to be won from this area when it is thoroughly prospected and opened up.

I cannot hold out much hope that the coal which may be taken from these areas will be of any better quality than that which is already being obtained from the neighbouring mines, but the only way to ascertain the quality and probable quantity is to have a sufficient amount of prospecting either by shafts or bores done to obtain the necessary data.

With so little work done on the outcrops surrounding this area and the well-known irregularity of development of the coal it is impossible to assert definitely that payable coal of good quality will be found over "Leeuwen Kuil" and the northern end of "Roman Fontein." It would seem to me, however, from the fact of the recurrence of fair quality coal at Woolf's, the Cape Collieries, and Deep Kloof, that it is possible there may be between those places and the outcrop on "Leeuwen Kuil" and the Stormberg river an extension under this area of the coal of Deep Kloof, Cape Collieries, and Woolf's. As can be seen from Plate IX., this area is of considerable extent, and could produce a very large quantity of coal if the latter proved of fair quality. I am of opinion that the prospects are sufficiently good to warrant at least the prospecting of this area. So far as my examination extended, it seems to me that this area presents features which point it out from all others in the district as one in which prospecting might be undertaken with advantage.

With reference to prospecting by bores or shafts, I would suggest that, in those positions where the coal horizon is at no great depth from the surface, shafts should be sunk, and also where the position of the prospecting shaft would be such that it would be useful as an air shaft. On the farm "Roman Fontein" I would suggest the following positions for bores or shafts: The two first should be placed on a line between the mouth of the principal adit at Woolf's mine and the conical hill called Beacon Kop. The first should be 600 yards from the mouth of the adit and the second 600 yards further on. The others, placed approximately east and west, should be put down in the valley, and each should be 600 yards from the other.

On "Leeuwen Kuil" the bores or shafts for prospecting purposes should be placed as follows, the first about 600 yards in a westerly direction from the house, and the others not less than that distance apart. The furthest west bore should be put well up the valley towards the Cape Collieries boundary.

Such a scheme of prospecting would furnish the information necessary to enable the Government to decide whether or not the properties were worth taking over.

In conclusion, I have to thank the Engineer-in-charge of the Cape Collieries Railway Line, Mr. McConochie, for the great assistance he gave me during my examination of the country.

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EXPLANATION

OF

PLATES.

Unless otherwise stated, the figures in Plates I., II., and III. represent the specimens of the natural size.

BRITISH COLUMBIA.

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Scale = 16 statute miles to 1 inch, $\frac{1}{1,013,700}$, 1899.
Geological Sketch Map of the Desert Sandstone Table Land between the Palmer and Mossman Waters, by R. L. Jack, Government Geologist.
Scale = 40 chains to 1 inch, 1896.
Geological Map of Charters Tower's Goldfield, by R. L. Jack and A. G. Maitland.
Scale = 4 chains to 1 inch, 1898.
Geological Map of part of Gympie Goldfield, by W. H. Rands.
Scale = 4 chains to 1 inch, 1899.
Plan of the Palmer District, compiled by R. L. Jack.
Scale = 2 miles to 1 inch, 1896.
Map of the Reefs, Maytown Neighbourhood, Palmer Goldfield.
Scale = 20 chains to 1 inch, 1896.
Plan of Dunbanda and Dinmore Districts Ipswich Coal-field, by R. D. Graham.
Scale = 20 chains to 1 inch, 1898.
Sections across Coal Seams, Ipswich Coal-field, by R. D. Graham.
Stratigraphical Sections, Dunbanda and Dinmore District, by R. D. Graham.
Scale = Columns 60 feet to 1 inch. Coal seams 4 feet to 1 inch.

From the Director of the Geological Survey of Portugal.

Carte Geologica de Portugal, por J. F. N. Delgado e Paul Choffat.
Escala $\frac{1}{500,000}$, 1899.

From the Director of the Geological Survey of Canada.

Geological Map of the Dominion of Canada (Western Sheet).
Scale, 50 miles = 1 inch. Edition of 1901.

From the Director of the Geological Survey of Western Australia.

Geological Sketch Map of Lennonville Murchison Gold Field, by A. Gibb Maitland and C. G. Gibson.
Scale, 15 chains to 1 inch.
Geological Map of Coolgarlie, by A. G. Maitland and W. D. Campbell.
Scale, 10 chains to 1 inch.

EXPLANATION

OF

PLATES.

Unless otherwise stated, the figures in Plates I., II., and III. represent the specimens of the natural size.

PLATE I.

Trigonarca umzambaniensis, *Baily, sp.*

Fig. 1.—An imperfect right valve, with sculpture.
2.—An imperfect left valve, with sculpture.
3.—The subject of Fig. 2 seen from the dorsal side to show the abrupt posterior slope and generally flattened outline of the valve.
4.—Internal cast of a smaller right valve, showing the pallial line and crenulated inner ventral margin.
5.—Portion of the area and cardinal margin of the subject of Fig. 1.

Protocardium hillanum, *Sby., sp., var.* umkwelanensis, *Eth. fil.*

6.—A right valve exhibiting the concentric and radiate sculpture.

Mytilus (?), *sp. ind.*

7.—Portion of a right valve, possibly referable to this genus.

Eriphyla (?) Rupert-Jonesi, *Eth. fil.*

8.—A nearly complete right valve.

Tapes (?), *sp. ind.*

9.—A nearly complete left valve, with a portion of the sculpture preserved.

Latiarca natalensis, *Baily, sp.*

10.—Portion of a right valve.
11.—Nearly complete right valve of a young individual.
12.—Portion of a left valve, with the sculpture preserved.
12A.—A small portion of sculpture from Fig. 12 enlarged.

Cicatrea (?), *sp. ind.*

13.—Portion of a right valve (cast), with a sharp diagonal ridge and steep posterior slope.

Trigonia umkwelanensis, *Eth. fil.*

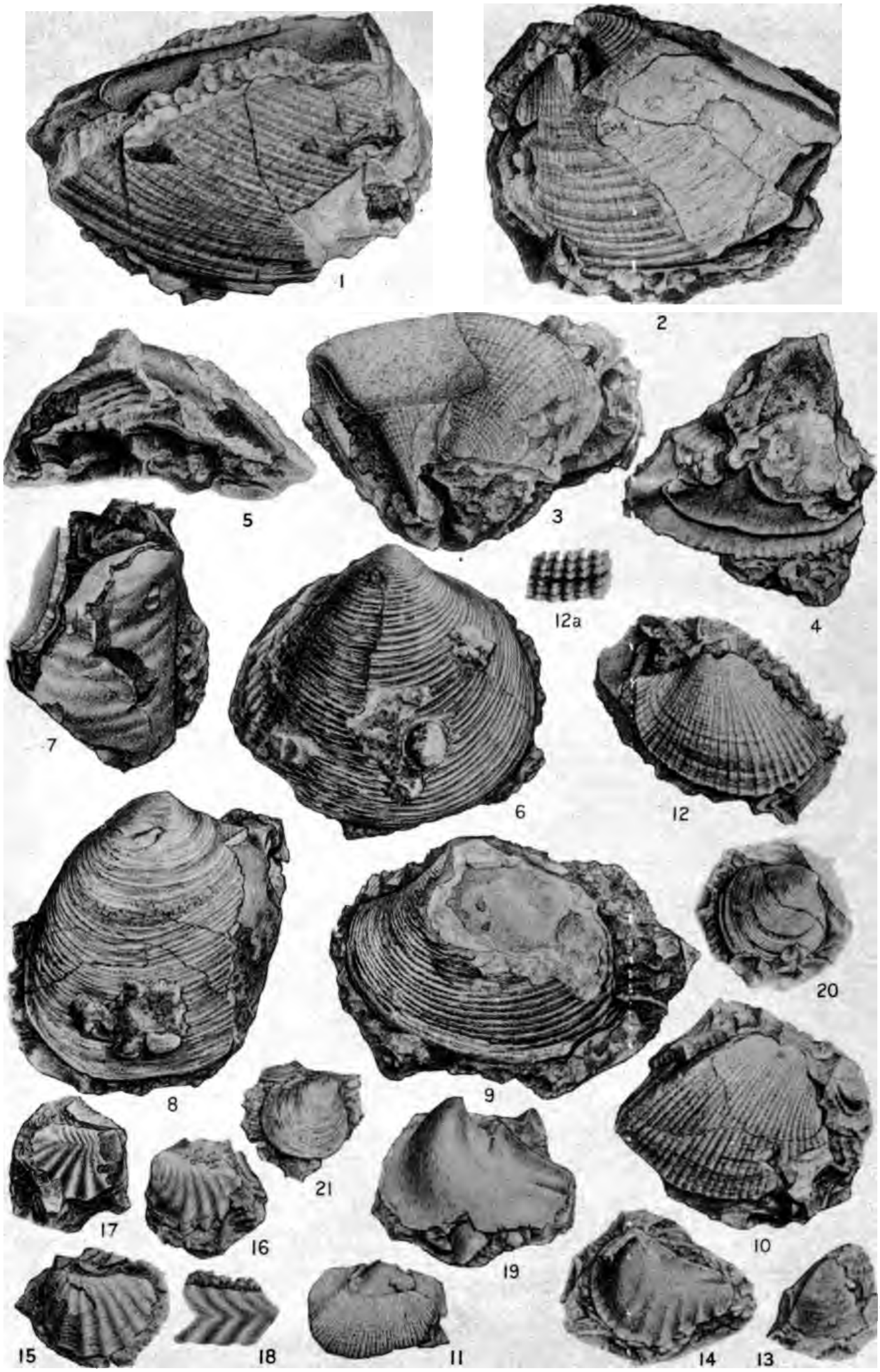
14.—Internal cast of a left valve.
15.—A testaceous left valve.
16.—Similar to Fig. 15.
17.—Portion of a testaceous right valve, with the sub-concentric rugæ on the posterior slope.
18.—A portion of the posterior slope of the specimen represented by Fig. 17—x 2.
19.—Internal cast of a full-grown left valve.

Eriphyla lenticularis, *Goldf. sp.*

20.—A nearly complete right valve.
21.—A smaller and similar specimen.

GEOL.SUR.OF NATAL.

PLATE I.



Frank R. Leggatt del.

West, Newman, London.

PLATE II.

Ostrea, *sps. ind.*

Fig. 1.—Internal cast of an *Ostrea*-like shell, with a sub-central adductor impression.
2.—A small thin flat valve, with an obscure umbo and a few concentric laminæ—x 2.

Exogyra (?), *sp. ind.*

3.—A thin valve, possibly referable to this genus, resembling *Placunopsis imbricata*, Tate.
4.—Another specimen allied to *Ostrea* (*Exogyra*) *jonesiana*, Tate.
5.—An internal cast.
6.—Another example similar to Fig. 3—x 2.

Melina Andersoni, *Eth. fil.*

7.—A left valve, more or less perfect, with strong concentric growth rugæ.
8.—Right and left valves of the same individual.
9.—A right valve.
10.—Portion of the cardinal margin exhibiting resilifers—x 2.

Gervillia, *sps. ind.*

11.—A small form, after the type of *G. linguloides*, Forbes—x 2.
12.—A second species to some extent resembling *G. alæformis*, D'Orb.—x 2.

Neithea (?), *sp. ind.*

13.—Portion of an internal cast of the convex valve.

Cardium Bullen-Newtoni, *Eth. fil.*

14.—Internal cast of a more or less perfect internal cast.
15.—A similar but larger example, exhibiting the strong diagonal ridge and steep posterior slope.
16.—A left valve showing traces of sculpture.

Mactra (?) zulu, *Eth. fil.*

17.—A left (?) valve retaining the test and sculpture—x 2.
18.—Another example of the same—x 2.
19.—The regular concentric sculpture—x 3.

Cytherea (?) kaffraria, *Eth. fil.*

20.—A nearly complete right valve, with the remains of sculpture lines.
21.—An imperfect internal cast of a left valve.
22.—Sculpture—x 3.

Donax Andersoni, *Eth. fil.*

23.—A left valve, with nearly the whole of the test preserved, exhibiting radiate sculpture—x 2.
24.—Internal cast of a left valve—x 2.
25.—Partial internal cast of a left valve—x 2.

Corbula (?), *sp. ind.*

26.—A left (?) valve retaining the test and sculpture—x 2.
27.—Sculpture—x 3.

Zaria Bonei, *Baily, sp.*

28.—A specimen showing eight whorls, each whorl with three revolving carinæ—x 3.
29.—Another individual with six whorls preserved, and a like number of revolving carinæ—x 3.
30.—A whorl on which there are three principal revolving carinæ, and supplementary intermediate ones—x 3.
31.—An entire whorl, and portion of a second with revolving carinæ similar to those of Fig. 30, but more oblique—x 3.

Gyrodes, *sp. ind.*

32.—Body-whorl and portion of the penultimate whorl.

Cylichna fusuliniformis, *Eth. fil.*

33.—A specimen exhibiting the sculpture—x 3.
34.—Apex with the immersed spire—x 3.

Solarium, *sp. ind.*

35.—A specimen seen from above—x 2.
36.—The same lateral view—x 2.
37.—Sculpture—x 2.

Actæonina Atherstoni, *Sharpe, sp., var.* umkwelanensis, *Eth. fil.*

38.—An example with sculpture, lateral view—x 3.

GEOL.SUR.OF NATAL. PLATE II.

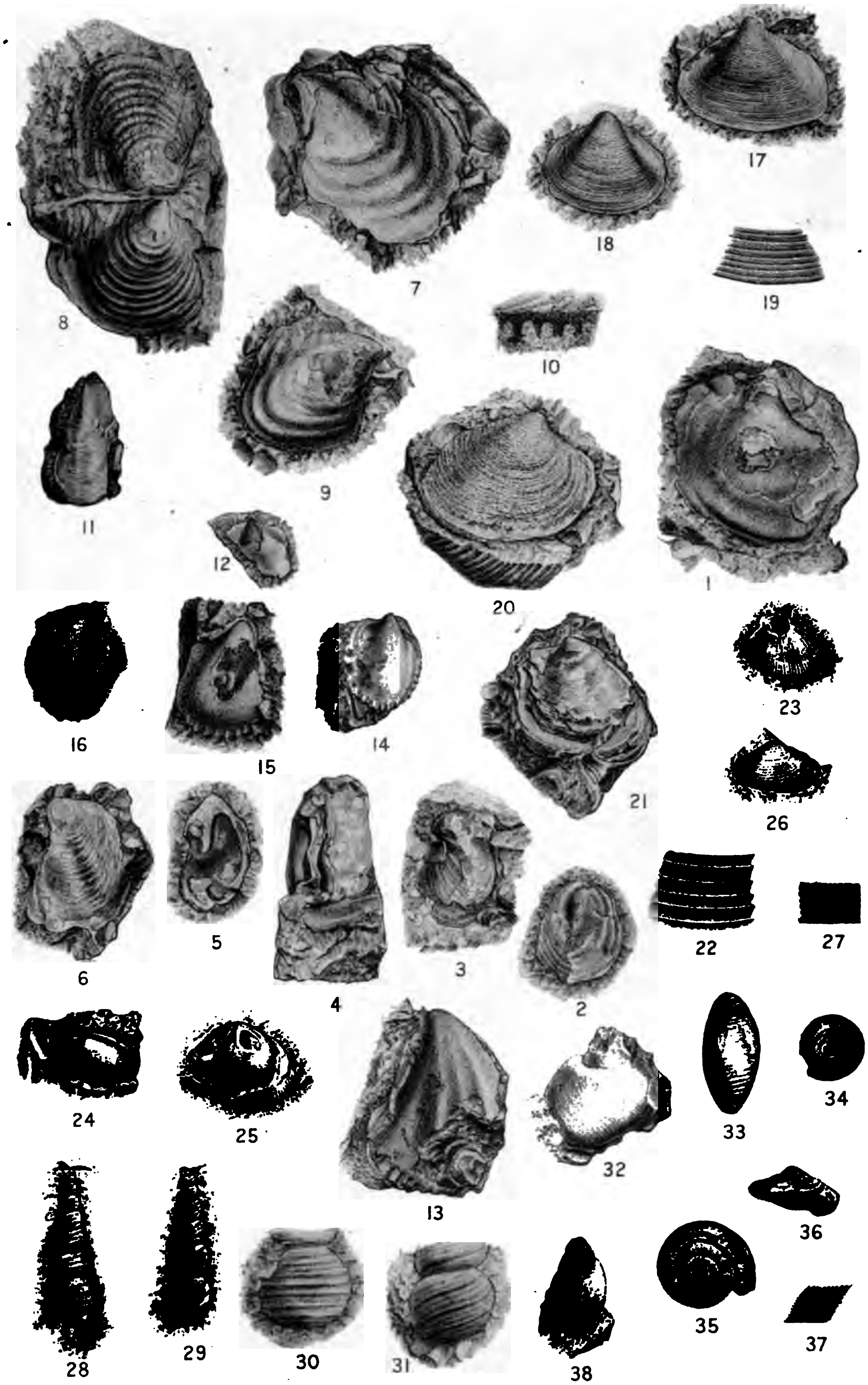


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PLATE III.

GYRODES, *sp ind.*

FIG. 1.—A shell of three whorls, with delicate oblique linear sculpture—x 3.

CHEMNITZIA SUTHERLANDI, *Baily* (?).

2.—Portions of two whorls with traces of sigmoidal linear sculpture—x 3.

PATELLA (?), *sp. ind.*

3.—A much exfoliated shell, possibly referable to this genus.

ALARIA (?) BAILYI, *Eth. fil.*

4.—An individual of seven whorls, inclusive of the body-whorl in part, exhibiting strong costæ on the four middle whorls, delicate lines of growth, but no tubercles on the body-whorl, and delicate transverse sculpture below the sutures—x 2.

5.—Body-whorl and three adjacent whorls; the three upper with costæ as in Fig. 4, and the body-whorl with obtuse tubercles, lines of growth, and broad flattened wing, with its entire margin.

6.—An imperfect body-whorl, with remains of the penultimate and anti-penultimate whorls; the body-whorl retaining the base of the anterior canal.

7.—Body-whorl exhibiting the obtuse tubercles and broken anterior canal.

8.—Two of the whorls (intermediate) exhibiting the costæ and sutural cross lineation—x 4.

8A.—Pupa-like apex—x 2.

ZARIA BONEI, *Baily*, *sp.* (?).

9.—Three whorls, each whorl with three strong oblique revolving carinæ—x 4.

PYROPSIS (?), *sp. ind.*

10.—An imperfect shell, possibly referable to this genus.

11.—The same specimen (Fig. 10) displaying the mouth.

FULGURARIA (?), *sp. ind.*

12.—Portion of an imperfect shell, having some of the characters of this genus, lower [view.

13.—The same specimen (Fig. 12) seen from the upper side.

CYLICHNA GRIESBACHI, *Eth. fil.*

14.—An example seen from the upper side, exhibiting the revolving striæ on the anterior part and the longitudinal striæ on the posterior portion of the whorl—3.

15.—The apex of Fig. 14, with immersed whorls—x 3.

PLACENTICERAS KAFFRARIUM, *Eth. fil.*

16.—About one-half of the Ammonite, with wide-apart obtuse ribs, and obtuse tubercles around the umbilical cavity.

PLACENTICERAS UMKWELANENSIS, *Eth. fil.*

17.—The Ammonite, side view.

18.—Portion of a larger specimen, showing weathered sutures.

19.—Section, naturally fractured, displaying lobes and saddles.

20.—The venter with keel.

CRENICERAS (?), *sp. ind.*

21.—Portion of a whorl with costæ, abdominal tubercles, and smaller tubercles along [the venter—x 3.

22.—The venter with its small tubercles—x 3.

HAMITES (?), *sp. ind.*

23.—Portion of a shell, with plain horizontal costæ—x 2.

BACULITES (?), *sp. ind.*

24.—Fragment possibly referable to this genus.

LAMNA, *sp. ind.*

25.—Basal portion of a tooth—x 2.

SPINE.

26.—Imperfect spine, undetermined—x 2.

GEOL.SUR. OF NATAL.

PLATE III.

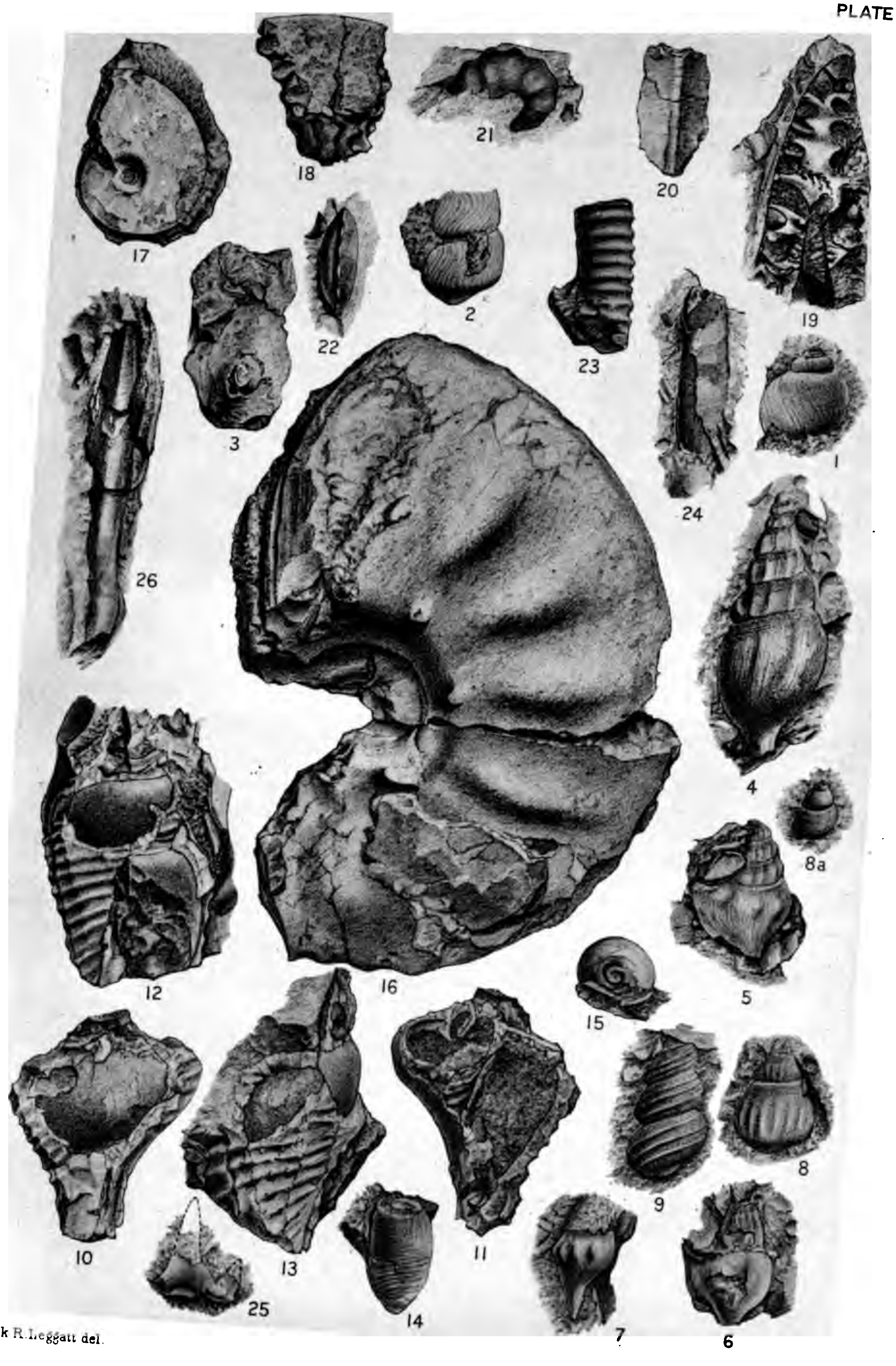

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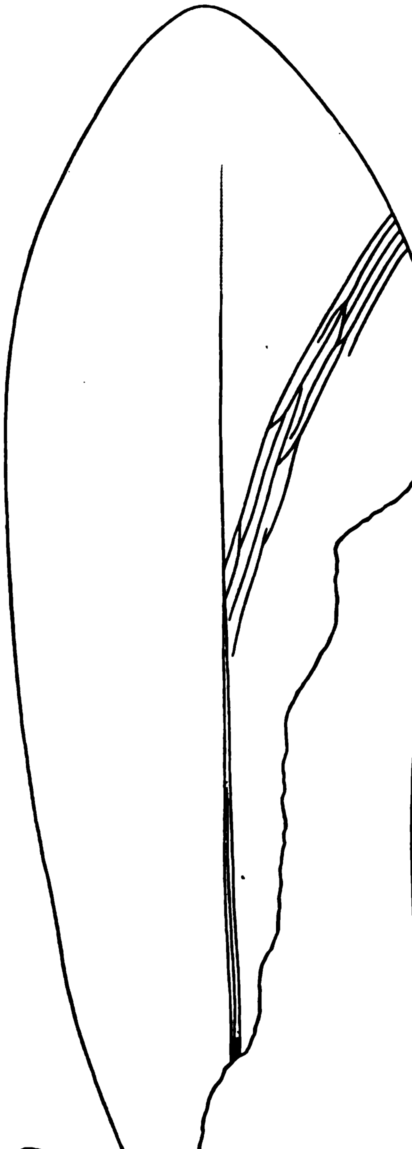
PLATE IV.

Fossil Plants from the Umhlali Beach, Victoria County, Natal.

Fig. 1.—*Glossopteris Browniana*, Brongn. No. 410B, Geol. Sur. Coll. Nat. size.
2.—*Glossopteris Browniana*, var. *Indica*, Bunbury. No. 418B, Geol. Sur. Coll. Nat. size.
3.—*Glossopteris Browniana*, var. *angustifolia*, Brongn. No. 414A, Geol. Sur. Coll. Nat. size.
4.—*Glossopteris Browniana*, var. *angustifolia*, Brongn. No. 374, Geol. Sur. Coll. Nat. size.
5.—Scale-leaf of *Glossopteris Browniana*, Brongn. No. 372, Geol. Sur. Coll. Nat. size.
6.—Scale-leaf of *Glossopteris Browniana*, Brongn. No. 429, Geol. Sur. Coll. Nat. size.
7.—A small leaf similar to *Gangamopteris cyclopteroides*, var. *attenuata*, Feistmantel. No. 314, Geol. Sur. Coll.
8.—*Noeggerathiopsis* (?), sp. No. 430, Geol. Sur. Coll. Nat. size.



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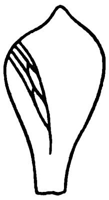

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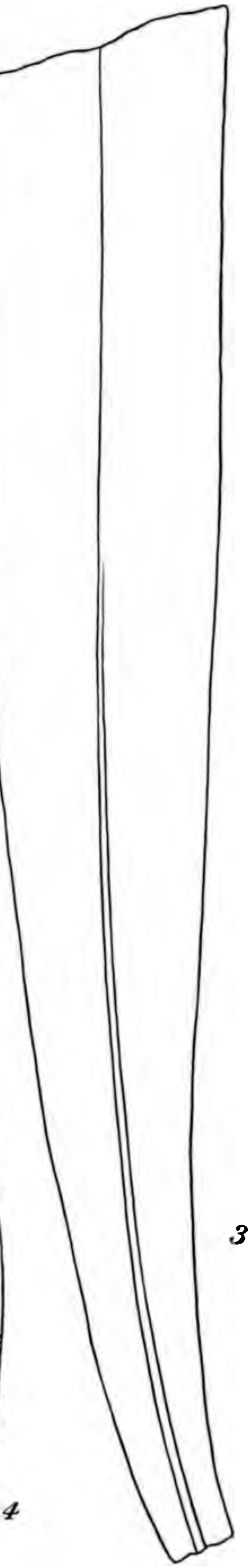

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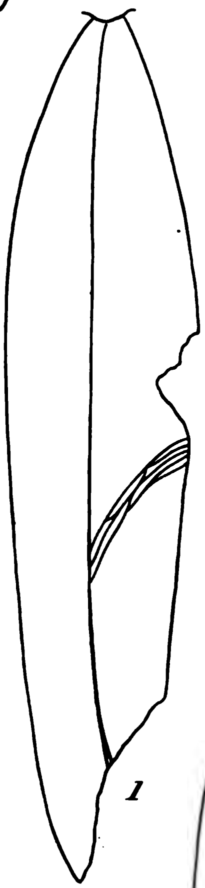

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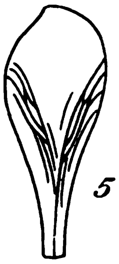

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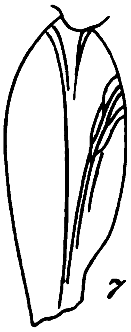

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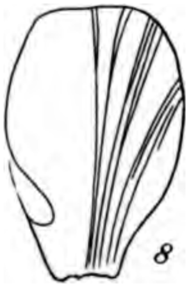

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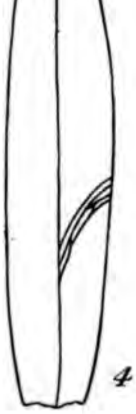

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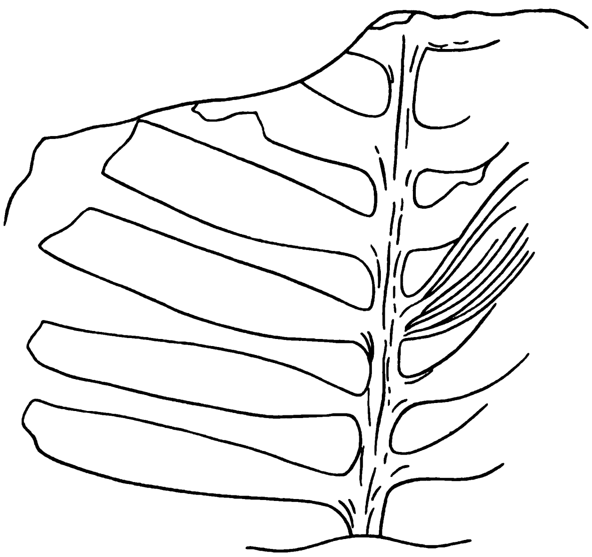
West,Newman lith.

PLATE V.

FOSSIL PLANTS FROM THE LUTIN RIVER, IMPENDHLA DISTRICT, BASE OF DRAKENSBERG RANGE.

FIG. 9.—*Pterophyllum*, probably *Footeanum*, Feistmantel. No. 562, Geol. Sur. Coll. Nat. size.
9A.—Portion of Fig. 9 enlarged.
10.—Doubtful Gymnospermous plant. No. 563, Geol. Sur. Coll. Nat. size.
11.—Doubtful Gymnospermous plant. No. 562, Geol. Sur. Coll. Nat. size.
11A.—Portion of Fig. 11 enlarged.

PLATE V.



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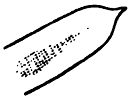

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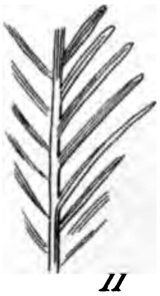

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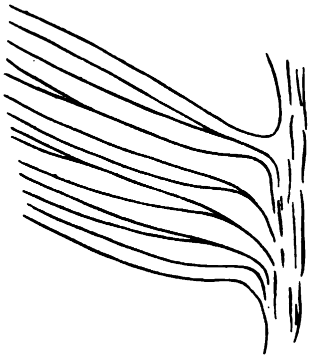

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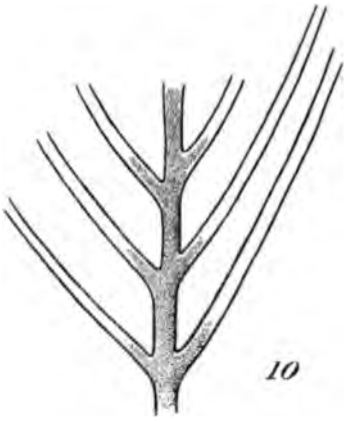

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PLATE VI.

FIG. 1.—Section across Ulundi Plain, showing on the east an outlier of glacial Ecca Conglomerate capping the Table Mountain Sandstones of the Uvula Range; the lower sandy bed, outcropping in the bed of the creek, in the middle of the plain; and the upper sandy bed, outcropping from among the glacial Ecca Conglomerate on the hill to the west, which is capped by a basaltic sill.

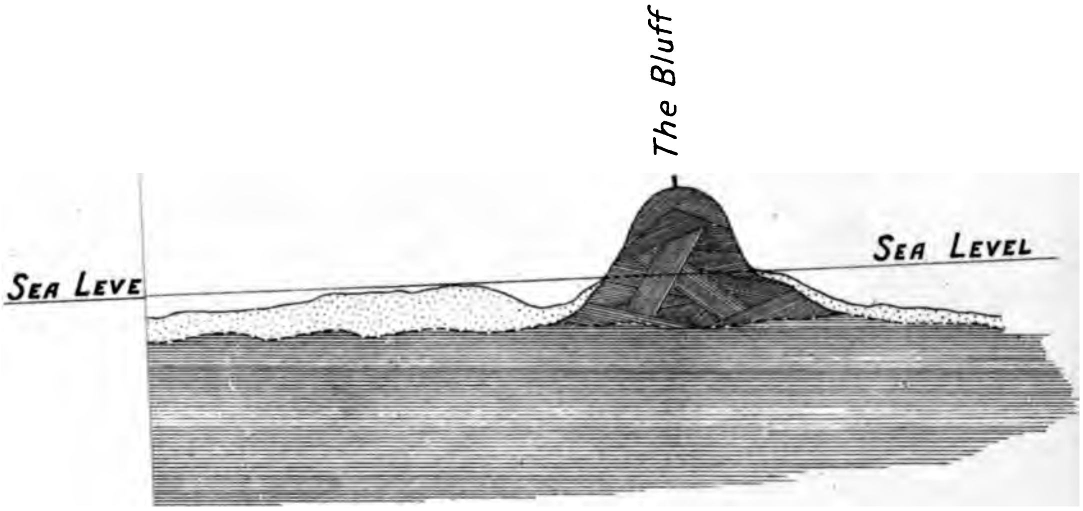
2.—Section of the south-eastern side of the Umhlatuzi river valley, some miles to the north of Eshowe; showing the difference of level at which the glacial Ecca Conglomerate occurs.

A.S.Board.

PLATE VII

Geological section from the Bluff to the Umbilo river, showing the Ecca Shales dipping at a low angle off the glacial Ecca Conglomerate of the Berea, below the Cretaceous (?) Sandstones of the Bluff, which rest unconformably upon them.

PLATE VII.



☐ Patlightly unconformable on Dwyka Conglomerate

A.S Board.

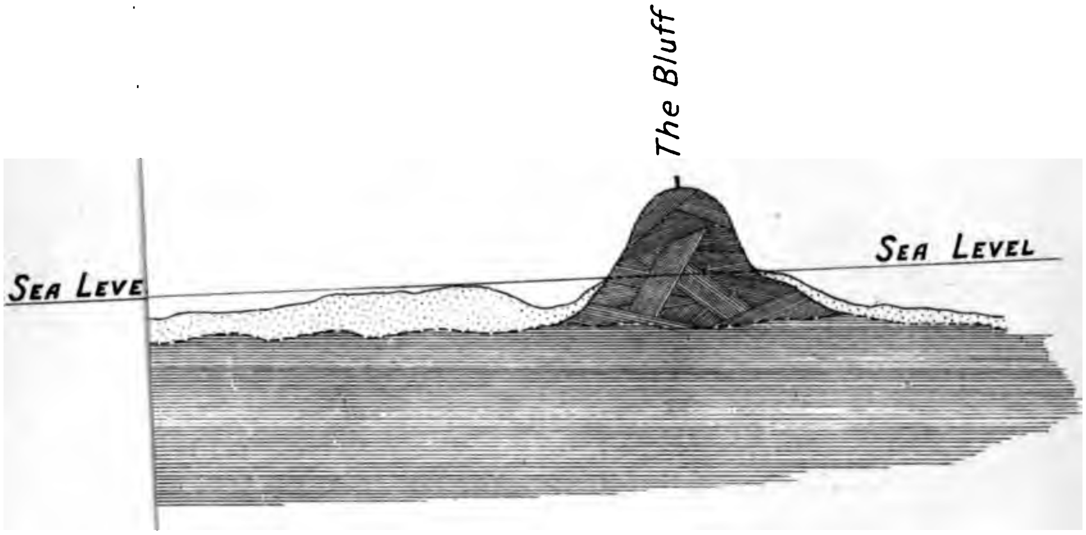
West, Newman photo lith.

PLATE VII.

Geological section from the Bluff to the Umbilo river, showing the Ecca Shales dipping at a low angle off the glacial Ecca Conglomerate of the Berea, below the Cretaceous (?) Sandstones of the Bluff, which rest unconformably upon them.

GEOL.SUR.OF NAT

PLATE VII.



☐ Palightly unconformable on Dwyka Conglomerate

A.S Board.

West, Newman photo lith.

2A

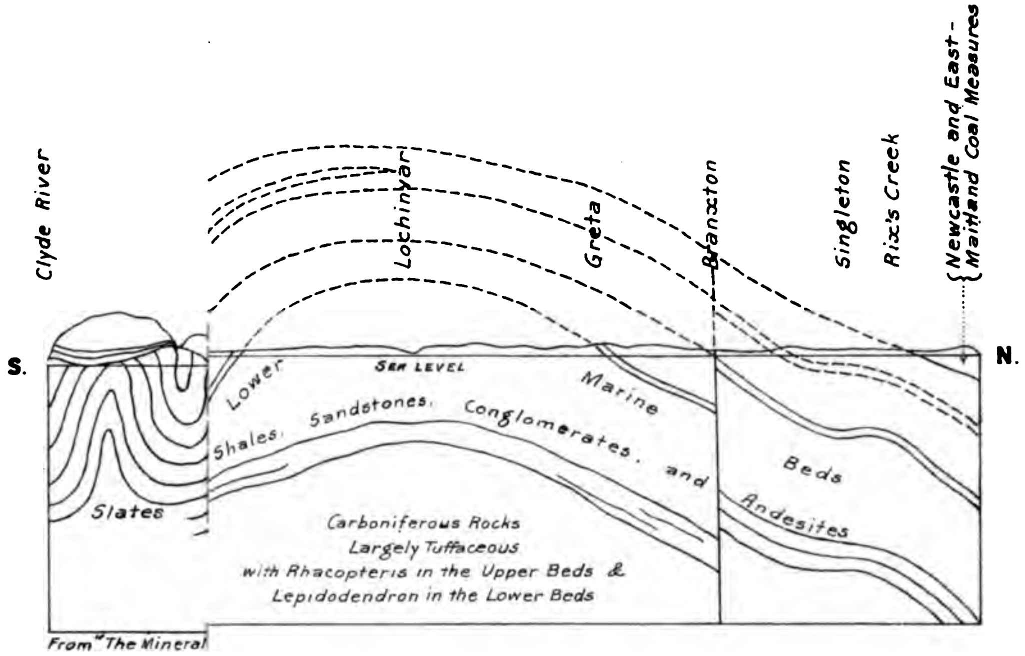
PLATE VIII.

FIG. 1.—Geological section showing the structure of the main coal-basin of New South Wales, for comparison with the occurrence of the Ecca Series at the Bluff, Durban.

2.—Geological section through the Bluff, Durban, Natal.

GEOL.SUR.OF NAT

PLATE VIII.


Clyde River
Lochinvar
Greta
Branxton
Singleton
Rix's Creek
Newcastle and East-Maitland Coal Measures
S.
N.
Sea Level
Lower Marine Shales, Sandstones, Conglomerates, and Beds
Andesites
Slates
Carboniferous Rocks
Largely Tuffaceous
with Rhacopteris in the Upper Beds &
Lepidodendron in the Lower Beds

From "The Mineral

Ecca Series.

A. S. Bo

West, Newman photo-lith.

PLATE IX.

Geological map of the district to the east of Molteno, Cape Colony, showing the Stormberg Coal-Measures, with their intrusive rocks. The solid black line shows the actual coal outcrop. The broken black line shows the outcrops of the same horizon where coal does not occur.

The half tint crimson areas are dykes and sills of basalt.

The uncoloured areas are the Stormberg Series.

╲ Fault ↘ Dip

GEOL.SUR.OF NATAL.

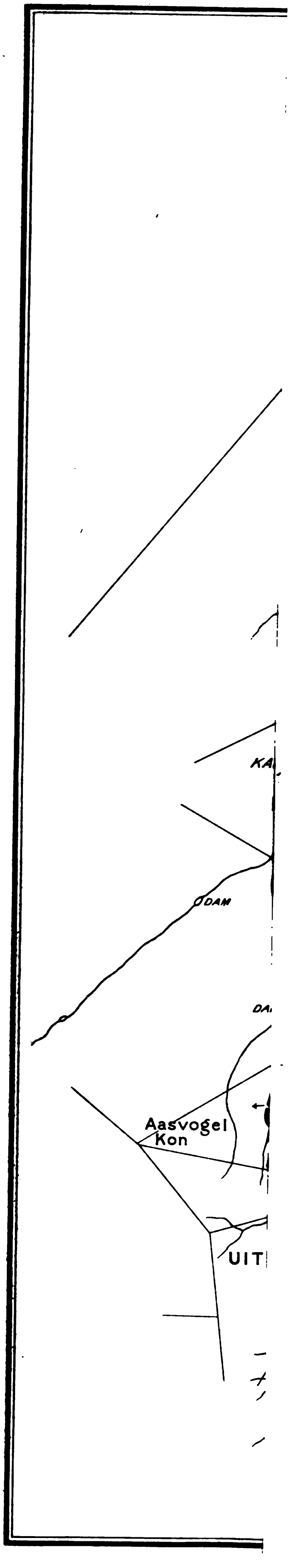
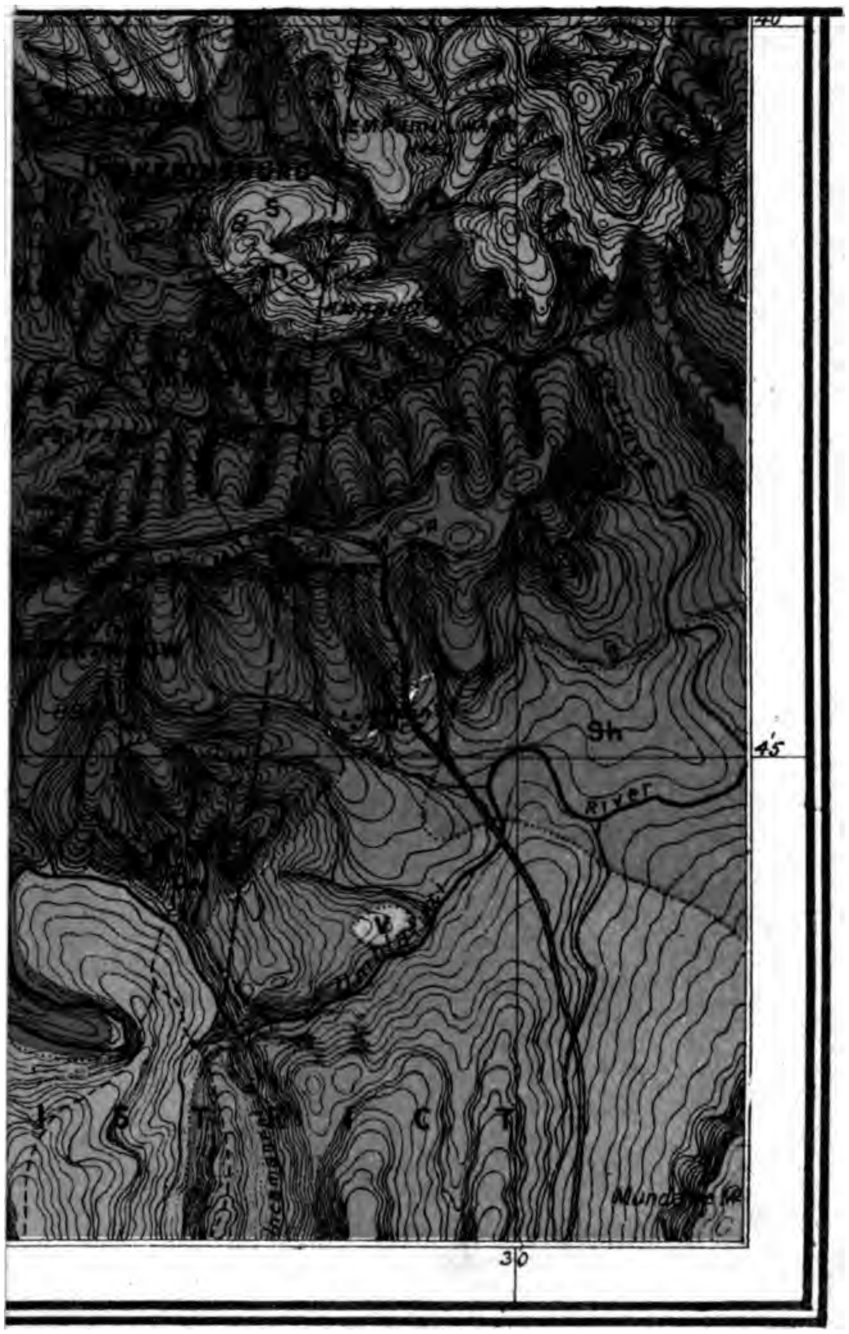


PLATE X.

Geological map of the Melmoth District, Zululand.

PLATE X.



West, Newman chromo.

PLATE XI.

Geological sketch map of Zululand, containing additional geological information obtained during the field work of 1901–1902.

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